# SOYUZ

## from the Guiana Space Centre

## User's Manual

Issue ***Draft*** – January 06

**Issued and approved by Arianespace**

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# Preface

This Soyuz User's Manual provides essential data on the Soyuz launch system, which together with Ariane 5 and Vega constitutes the European Space Transportation union.

These launch systems are operated by Arianespace from the same spaceport: the Guiana Space Centre.

This document contains the essential data which is necessary:

- To assess compatibility of a spacecraft and spacecraft mission with launch system,
- To constitute the general launch service provisions and specifications,
- To initiate the preparation of all technical and operational documentation related to a launch of any spacecraft on the launch vehicle.

Inquiries concerning clarification or interpretation of this manual should be directed to the addresses listed below. Comments and suggestions on all aspects of this manual are encouraged and appreciated.

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This document will be revised periodically. In case of modification introduced after the present issue, the updated pages of the document will be provided on the Arianespace website *www.arianespace.com* before the next publication.

# Foreword

## Arianespace : the business friendly launch service company …

### Tuned to customer needs

Arianespace is a fully industrial, operational and commercial company providing complete personalized launch solutions.

In house flexibility is proposed through a family of powerful, reliable and flexible launch vehicles operated from the same spaceport and providing a complete range of lift capabilities:

- ♦ Ariane 5, the heavy lift workhorse for GTO missions, provides through the dual launch policy the best value for money,
- ♦ Soyuz, the Ariane 5 complement in GTO, is also perfectly suited for medium mass specific missions (LEO, escape …),
- ♦ Vega offers an affordable launch solution for small to medium missions.

Arianespace combines low risk and flight proven launch systems with financing, insurance and back-up services providing reactivity for quick responses and decisions and tailor-made solutions for start-ups or established players.

With offices in the United States, Japan, Singapore and Europe, and with program representatives elsewhere in the world, Arianespace is committed to forging service package that meet our Customer's requirements as closely as possible.

### An experienced and reliable company

Arianespace established the most trusted commercial launch system satisfactorily managing more than 250 contracts, the industry record. Arianespace competitiveness is demonstrated by the market's largest order book that confirms the past and present confidence of Arianespace worldwide customers. Arianespace has a unique processing and launch experience with all commercial satellite platforms as well as with very demanding scientific missions.

### A dependable long term partner

Backed by the combined recourses of its shareholders and the European and national Space Agencies, Arianespace relies on the scientific and technical expertise of its European and other country's industrial partners. European political support, periodically confirmed, and international cooperation agreements at state level (Russia, Ukraine …), brings non comparable advantages.

## The reference system: Any time, any mass, to any orbit …

# User's Manual Configuration Control Sheet

| Date | Revision number | Change description | Approval |
|---|---|---|---|
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Note:

The present Manual is in close link with the User's Manual of Soyuz launched from Baikonur (ST-GTD-SUM-01 Issue 3, Revision 0, April 2001). In case of conflict between the two documents the present Manual takes precedence for launches from the Guiana Space Center (CSG).

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**CHAPTER 7. MISSION INTEGRATION AND MANAGEMENT**

# Acronyms, abbreviations and definition

| | | | |
|---|---|---|---|
| | ω | Argument of perigee | |
| | Ω | Ascending node | |
| | $\Omega_D$ | Descending node | |
| | $a$ | Semi-major axis | |
| | $e$ | Eccentricity | |
| | $Z_a$, $h_a$ | Apogee altitude | |
| | $Z_p$, $h_p$ | Perigee altitude | |
| | $i$ | Inclination | |
| **A** | | | |
| | ABM | **A**pogee **B**oost **M**otor | |
| | ACS | **Attitude Control System** | |
| | ACU | Payload adapter | **A**dapteur **C**harge **U**tile |
| | ACY | Raising Cylinder | |
| | AE | **A**rianespace | |
| | ARS | Satellite ground stations network Assistant | **A**djoint **R**éseau **S**ol |
| | AULV | **A**pplication to **U**se **A**rianespace **L**aunch **V**ehicle | |
| | AZ | **A**zimuth | **A**zimut |
| **B** | | | |
| | BCL | Launch Vehicle Checkout System | |
| | BCO | Operations Coordination Office | |
| | BNBD | Low-level bipolar unbalanced | |
| | BT POC | Combined operations readiness review | **B**ilan **T**echnique **POC** |
| **C** | | | |
| | CAD | **C**omputer **A**ided **D**esign | |
| | CCTV | **C**losed-**C**ircuit **T**elevision **N**etwork | |
| | CCU | Payload Container | **C**ontainer **C**harge **U**tile |
| | CDL | Launch Control Building | **C**entre **d**e **L**ancement |
| | CDR | **C**ritical **D**esign **R**eview | |
| | CFRP | **C**arbon **F**iber **R**einforced **P**lastic | |
| | CG, CoG | **C**enter **of** **G**ravity | **C**entre de **G**ravité |
| | CLA | **C**oupled **L**oads **A**nalysis | |
| | CM | Mission Director | **C**hef de **M**ission |
| | CNES | French National Space Agency | **C**entre **N**ational d'**E**tude **S**patiales |
| | COEL | Launch Site Operations Manager | **C**hef des **O**pérations **E**nsemble de **L**ancement |
| | COTE | **C**heck-**O**ut **T**erminal **E**quipment | |
| | CP | Program director | **C**hef de **P**rogramme |
| | CPAP | Ariane production project manager | |
| | CPS | Spacecraft project manager | **C**hef de **P**rojet **S**atellite |
| | CRAL | Post Flight Debriefing | **C**ompte-**R**endu **A**pres **L**ancement |
| | CRE | Operational Reporting Network | **C**ompte-**R**endu d'**E**tat |

| | | | |
|---|---|---|---|
| | CSEL | Launch Complex Safety Officer | |
| | CSG | Guiana Space Centre | **C**entre **S**patial **G**uyanais |
| | CT | Technical Centre | **C**entre **T**echnique |
| | CVCM | **C**ollected **V**olatile **C**ondensable **M**aterial | |
| | CVI | | **C**ontrôle **V**isuel **I**mmédiat |
| | CU | Payload | **C**harge **U**tile |
| **D** | | | |
| | DAM | Mission analysis document | **D**ocument d'**A**nalyse de **M**ission |
| | DAMF | Final mission analysis document | **D**ocument d'**A**nalyse de **M**ission **Fi**nale |
| | DAMP | Preliminary mission analysis document | **D**ocument d'**A**nalyse de **M**ission **P**réliminaire |
| | DCI | Interface control file | **D**ocument de **C**ontrôle des **I**nterfaces |
| | DDO | Range operations manager | |
| | DEL | Flight Synthesis Report (FSR) | **D**ocument d'**E**valuation du **L**ancement |
| | DL | Launch requirements document | **D**emande de **L**ancement |
| | DMS | Spacecraft mission director | **D**irecteur de **M**ission **S**atellite |
| | DUA | Application to use Arianespace launch vehicles | **D**emande d'**U**tilisation **A**rianespace |
| | DV | Flight director | **D**irecteur **V**ol |
| **E** | | | |
| | EADS | **E**uropean **A**eronautic, **D**efense, and **S**pace Company | |
| | EDP | Hazardous primary circuits | |
| | EDS | Hazardous secondary circuits | |
| | EGSE | **E**lectrical **G**round **S**upport **E**quipment | |
| | ELA | Ariane launch site | **E**nsemble de **L**ancement **A**riane |
| | ELS | Soyuz Launch Site | Ensemble de Lancement Soyuz |
| | ELV | ELV S.p.A. (European Launch Vehicle) | |
| | EMC | **E**lectro**m**agnetic **C**ompatibility | |
| | EPCU | Payload preparation complex | **E**nsemble de **P**réparation des **C**harges **U**tiles |
| | ESA | **E**uropean **S**pace **A**gency | |
| | ESMC | **E**astern **S**pace **M**issile Center | |
| **F** | | | |
| | FAR | **F**ueling **A**uthorization **R**eview | |
| | FM | **F**requency **m**odulation | |
| | FM | **F**light **M**odel | |
| | FMA | **F**inal **M**ission **A**nalysis | |
| | FMAD | **F**inal **M**ission **A**nalysis **D**ocument | |
| | FMAR | **F**inal **M**ission **A**nalysis **R**eview | RAMF "Revue d'Analyse de Mission Finale" |
| | FQR | **F**inal **Q**ualification **R**eview | |
| **G** | | | |
| | GEO | **G**eosynchronous **E**quatorial **O**rbit | |

| | | | |
|---|---|---|---|
| | GRS | **G**eneral **R**ange **S**upport | |
| | GSE | **G**round **S**upport **E**quipment | |
| | GTO | **G**eostationary **T**ransfer **O**rbit | |
| | GTO | **G**eosynchronous **T**ransfer **O**rbit | |
| **H** | | | |
| | HEO | **H**ighly **E**lliptical **O**rbit | |
| | HPF | **H**azardous **P**rocessing **F**acility | |
| | HSF | **H**azardous **S**torage **F**acility | |
| | HV | **H**igh **V**oltage | |
| **I** | | | |
| | I/S | Interstage | |
| | ICD | **I**nterface **C**ontrol **D**ocument | |
| | IMU | **I**nertial **M**easurement Unit | |
| | IO | Operational Intersite Intercom system | **I**ntercom **O**perationelle |
| | ISCU | Payload safety officer | **I**ngénieur **S**auvegarde **CU** |
| | ISLA | Launch area safety officer | **I**ngénieur **S**auvegarde **L**anceur **A**riane |
| | ITAR | **I**nternational **T**raffic in **A**rms **R**egulations | |
| **K** | | | |
| | KM | **K**ick **m**otor | |
| | KRU | Kourou | |
| **L** | | | |
| | LAM | Measuring instrument laboratory | **La**boratoire **M**esures |
| | LBC | Check out equipment room | **L**aboratoire **B**anc de **C**ontrôle |
| | LEO | **L**ow-**E**arth **O**rbit | |
| | LL | **L**eased **L**ines | |
| | LOX | **L**iquid **Ox**ygen | |
| | LP | **L**aunch **P**ad | |
| | LRR | **L**aunch **R**eadiness **R**eview | Revue d'aptitude au lancement |
| | LSA | **L**aunch **S**ervice **A**greement | |
| | LTD | Data transmission links | **L**igne de **T**ransmission de **D**onnées |
| | LV | **L**aunch **V**ehicle | |
| | LW | **L**aunch **W**indow | |
| **M** | | | |
| | MCC | **M**ission **C**ontrol **C**entre | Centre de Contrôle |
| | MCI | Masses, balances and inertias | **M**asse, **C**entre de gravité, **I**nerties |
| | MCU | Payload mass | **M**asse **C**harge **U**tile |
| | MEO | **M**edium-**E**arth Orbit | |
| | MEOP | **M**aximum **E**xpected **O**perating **P**ressure | |
| | MGSE | **M**echanical **G**round **S**upport **E**quipment | |
| | MIK | Assembly and Integration Building (Russian acronym) | |
| | MMH | **M**ono**m**ethyl **H**ydrazine | |

| | | | |
|---|---|---|---|
| | MPS | **M**aster **P**rogram **S**chedule | |
| | MUSG | Soyuz from CSG user's manual | **M**anuel **U**tilisateur **S**oyuz du CS**G** |
| **N** | | | |
| | N/A | **N**ot **A**pplicable | |
| | NCR | **N**on-**C**onformity **R**eport | |
| | NTO | **N**itrogen **T**etroxide | |
| **O** | | | |
| | OASPL | Overall Acoustic Sound Pressure Level | |
| | OBC | **O**n **B**oard **C**omputer | |
| | OCOE | **O**verall **C**heck **O**ut **E**quipment | |
| **P** | | | |
| | PABX | **P**rivate **A**utomatic **B**ranch e**X**change | Central Téléphonique Privé |
| | PCM | **P**ulse **C**oded **M**odulation | |
| | PCU | Payload console | **P**upitre **C**harge **U**tile |
| | PDE | **P**ressurization/**D**epressurization **E**quipment | |
| | PDR | **P**reliminary **D**esign **R**eview | |
| | PFCU | Payload access platform | **P**late**F**orme **CU** |
| | PFM | **P**roto-**F**light **M**odel | |
| | PFT | Transport platform | **P**late**F**orme de **T**ransport |
| | PIP | Pyro Interception Plug | **P**rise d'**I**nterception **P**yrotechnique |
| | PLANET | **P**ayload **L**ocal **A**rea **NET**work | |
| | PMA | **P**reliminary **M**ission **A**nalysis | |
| | PMAD | **P**reliminary **M**ission **A**nalysis **D**ocument | |
| | PMAR | **P**reliminary **M**ission **A**nalysis **R**eview | RAMP "Revue d'Analyse de Mission Préliminaire") |
| | POC | Combined operations plan | **P**lan d'**O**pérations **C**ombinées |
| | POE | Electrical umbilical plug | **P**rise **O**mbilicale **E**lectrique |
| | POI | Interleaved Operation Plan | **P**lan d'**O**pérations **I**mbriquées |
| | POP | Pneumatic umbilical plug | **P**rise **O**mbilicale **P**neumatique |
| | POS | Spacecraft operations plan | **P**lan des **O**pérations **S**atellite |
| | PPF | **P**ayload **P**reparation **F**acility | |
| | PPLS | **P**ropellant and **P**ressurant **L**oading **S**ystems | |
| | PSCU | Payload safety console | **P**upitre **S**auvegarde **C**harge **U**tile |
| | PSD | **P**ower **S**pectral **D**ensity | |
| **Q** | | | |
| | QA | **Q**uality **A**ssurance | |
| | QR | **Q**ualification **R**eview | |
| | QSL | **Q**uasi-**S**tatic **L**oad (equivalent to design load factor) | |
| | QSM | **Q**uality **S**ystem **M**eeting | |
| | QSP | **Q**uality **S**ystem **P**resentation | |
| | QSR | **Q**uality **S**tatus **R**eview | |

| | | | |
|---|---|---|---|
| **R** | | | |
| | RAAN | **R**ight **A**scension of the **A**scending **N**ode | |
| | RAL | Launch readiness review | **R**evue d'**A**ptitude au **L**ancement |
| | RAMF | Final mission analysis review | **R**evue d'**A**nalyse de **M**ission **F**inale |
| | RAMP | Preliminary mission analysis review | **R**evue d'**A**nalyse de **M**ission **P**réliminaire |
| | RAV | Launch vehicle flight readiness review | **R**evue d'**A**ptitude au **V**ol du lanceur |
| | RF | **R**adio **F**requency | |
| | RMS | **R**oot **M**ean **S**quare | |
| | rpm | **R**evolutions **p**er **m**inute | |
| | RPS | Spacecraft preparation manager | **R**esponsable **P**réparation **S**atellite |
| | RS | Safety manager | **R**esponsable **S**auvegarde |
| | RSG | Ground safety officer | **R**esponsable **S**auvegarde Sol |
| | RSV | Flight safety officer | **R**esponsable **S**auvegarde **V**ol |
| | RTW | **R**adio **T**ransparent **W**indow | |
| **S** | | | |
| | S/C | Spacecraft | |
| | SCA | Attitude control system | **S**ystème de **C**ontrôle d'**A**ttitude |
| | SCOE | **S**pecial **C**heck **O**ut **E**quipment | |
| | SIW | **S**atellite **I**njection **W**indow | |
| | SONO | Public One-Way Announcement System | |
| | SOW | **S**tatement **O**f **W**ork | |
| | SPM | **S**olid **P**ropellant **M**otor | |
| | SRS | **S**hock **R**esponse **S**pectrum | |
| | SSO | **S**un-**S**ynchronous **O**rbit | |
| | STFO | Optical Fiber Data Transmission System | **S**ystème de **T**ransmission par **F**ibres **O**ptiques |
| | STM | **S**tructural **T**est **M**odel | |
| | SYLDSO | Payload internal carrying structure | **SY**stème de **L**ancement **D**ouble **SO**yuz |
| **T** | | | |
| | TBD | **T**o **B**e **D**efined | |
| | TC | **T**ele**c**ommand | |
| | TD | Countdown Time | **T**emps **D**écompté |
| | TM | **T**ele**m**etry | |
| | TML | **T**otal **M**ass **L**oss | |
| | TRR | **T**ransfer **R**eadiness **R**eview | |
| | TS | Point-To-Point Telephone Network | **T**éléphone **S**pécialisé |
| **U** | | | |
| | UC | **U**pper **C**omposite* | |
| | UCIF | **U**pper **C**omposite **I**ntegration **F**acility | |
| | UDMH | **U**nsym**m**etrical **D**i**m**ethyl **H**ydrazine | |
| | UT | **U**niversal **T**ime | |

| | | | |
|---|---|---|---|
| **V** | | | |
| | VEB | **V**ehicle **E**quipment **B**ay | |
| **W** | | | |
| | w.r.t. | **W**ith **R**eference **t**o/With Respect to | |
| **Z** | | | |
| | ZL | Launch Pad | **Z**one de **L**ancement |
| | ZSP | Pyrotechnics Storage facility | **Z**one de **S**tockage de **P**yrotechnique |

*Upper Composite, defined as the spacecraft, adapter and upper stage (if located under the fairing) encapsulated under the fairing with its interstage bay.

# INTRODUCTION Chapter 1

## 1.1. Purpose of the User's Manual

This User's Manual is intended to provide basic information on the Arianespace's launch services solution using the Soyuz launch system operated from the Guiana Space Centre along with Ariane 5 and Vega launch systems.

The content encompasses:

- the Soyuz launch vehicle (LV) description;
- performance and launch vehicle mission;
- environmental conditions imposed by the LV and corresponding requirements for spacecraft design and verification;
- description of interfaces between spacecraft and launch vehicle;
- payload processing and ground operations performed at the launch site;
- mission integration and management, including Customer's support carried out throughout the duration of the launch contract.

Together with the Payload Preparation Complex Manual (EPCU User's Manual) and the CSG Safety Regulations it will give readers sufficient information to assess the suitability of the Soyuz LV and its associated launch services to perform its mission and to assess the compatibility with the proposed launch vehicle. On completion of the feasibility phase, formal documentation will be established in accordance with the procedures outlined in Chapter 7.

For more detailed information, the reader is encouraged to contact Arianespace.

# PERFORMANCE AND LAUNCH MISSION Chapter 2

## 2.1. Introduction

This section provides the information necessary to make preliminary performance assessments for the Soyuz LV. The paragraphs that follow present the vehicle reference performance, typical accuracy, attitude orientation, and mission duration.

The provided data covers a wide range of missions from spacecraft delivery to geostationary transfer orbit (GTO), to injection into sun-synchronous and polar orbit, as well as low and high circular or elliptical orbit, and escape trajectories.

Performance data presented in this manual are not fully optimized as they do not take into account the specificity of the Customer's mission.

## 2.2. Performance definition

The performance figures given in this chapter are expressed in term of payload mass including:

- the spacecraft separated mass;
- the dual launch system (if used);
- the adapter or dispenser;

  Available payload adapters are shown in Appendix 4 and their masses are approximately:

  | | |
  |---|---|
  | Ø937-SF: | 45 kg |
  | Ø1194-SF: | 110 kg |
  | Ø1666-SF: | 100 kg |

Performance computations are based on the following main assumptions:

- Sufficient propellant reserve is assumed to reach the targeted orbit with a 99.7% probability except otherwise specified. The Fregat's fuel capacity is sufficient for deorbitation or for transfer to a safe orbit as required,
- Aerothermal flux at fairing jettisoning is less or equal to 1135 $W/m^2$.
- Altitude values are given with respect to a spherical earth radius of 6378 km.
- Launch from the CSG (French Guiana) taking into account the relevant CSG safety requirements. Nevertheless, the performance value may slightly vary for specific missions due to ground path and azimuth specific constraints. The customer is requested to contact Arianespace for accurate data.
- Data presented herein do not take into account additional equipment or services that may be requested, in particular, as function of mission duration.
- ST fairing
- RD-0110 (Soyuz 2-1a), and RD-0124 (Soyuz 2-1b) third stage engines

## 2.3. Typical mission profiles

A typical mission profile consists of the following three phases:

- Ascent of the first three stages of the LV
- Fregat upper stage flight profile for payload delivery to final orbit; and
- Fregat deorbitation or orbit disposal maneuvers.

### 2.3.1. Ascent of the first three stages

The flight profile is optimized for each mission. The upper composite (Fregat with payload) is separated on a sub-orbital path, Fregat being used, in most cases, to reach an intermediate parking orbit (the so-called intermediate orbit ascent profile), in other cases after separation from the third stage, a single Fregat boost may inject the upper composite into the targeted orbit (the so-called direct ascent profile). The optimum mission profile will be selected depending upon specific mission requirements.

A typical Soyuz three-stage ascent profile and the associated sequence of events are shown in Figure 2.1. A typical ground track for the lower three stages is presented in the Figure 2.2 (GTO mission). An example of the evolution of altitude and relative velocity during the ascent profile of the first three stages is presented in Figure 2.3.

Jettisoning of the payload fairing can take place at different times depending on the aero-thermal flux requirements on the payload. Typically, fairing separation takes place depending on the trajectory between 155 and 200 seconds from liftoff owing to aero-thermal flux limitations.

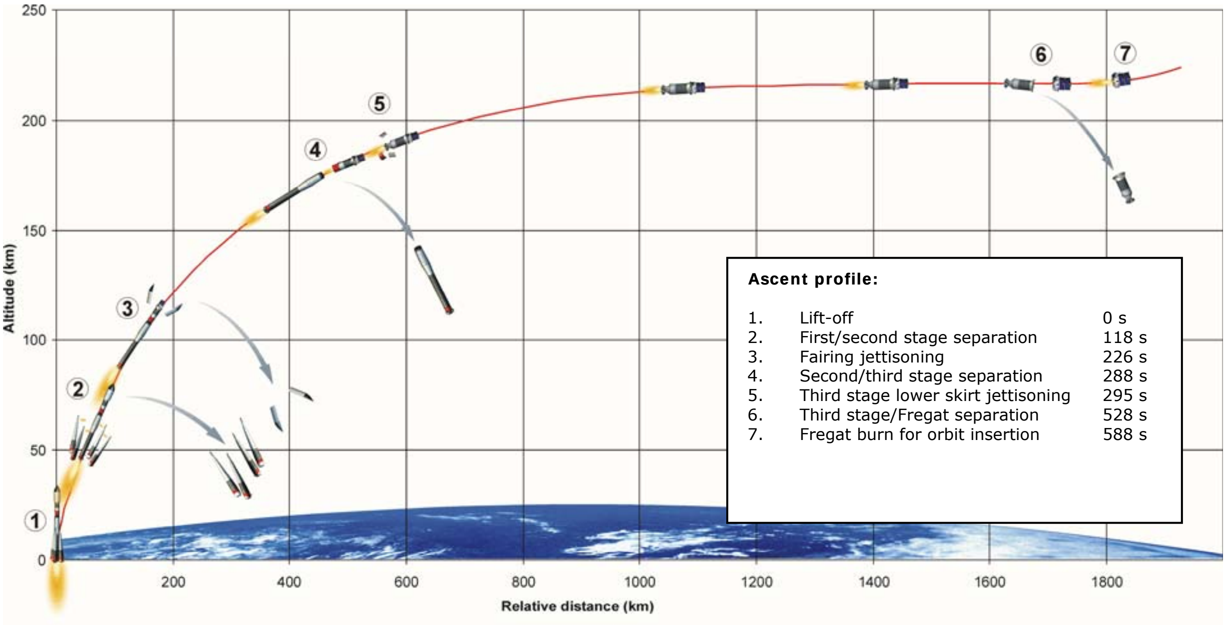


Figure 2.1 – Typical ascent profile

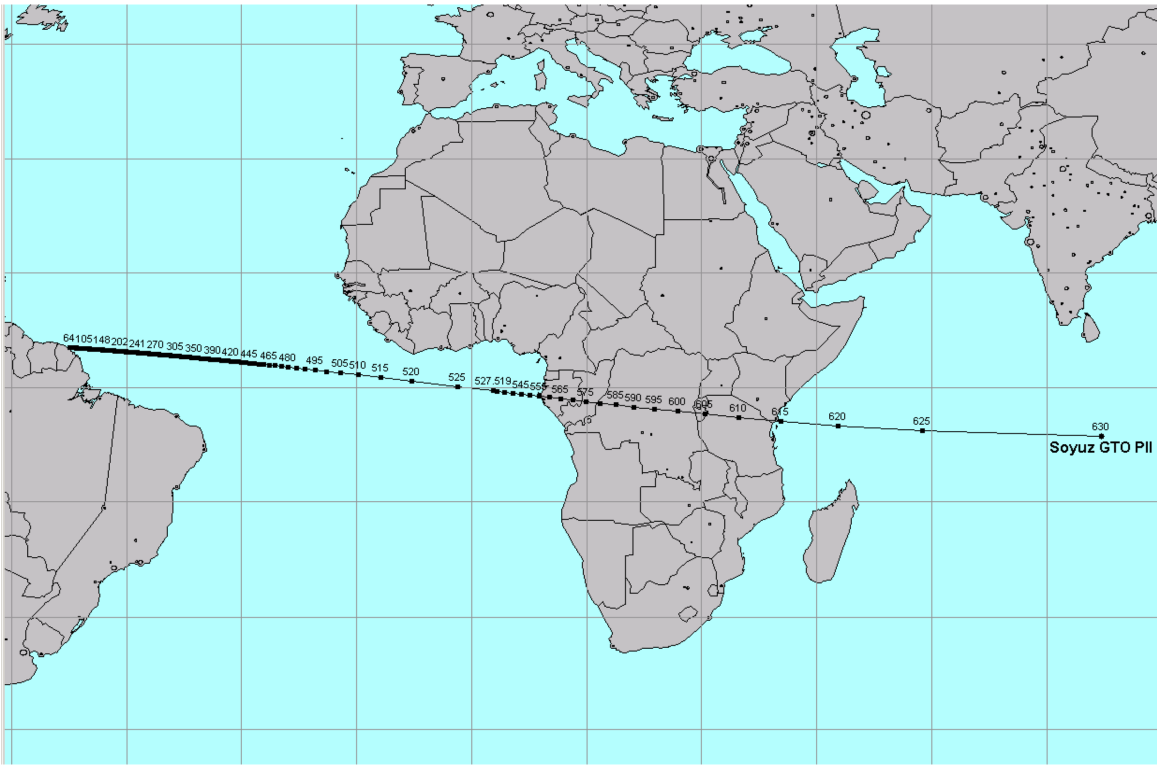


Figure 2.2 - Typical ground path for the Soyuz three stages (GTO mission)

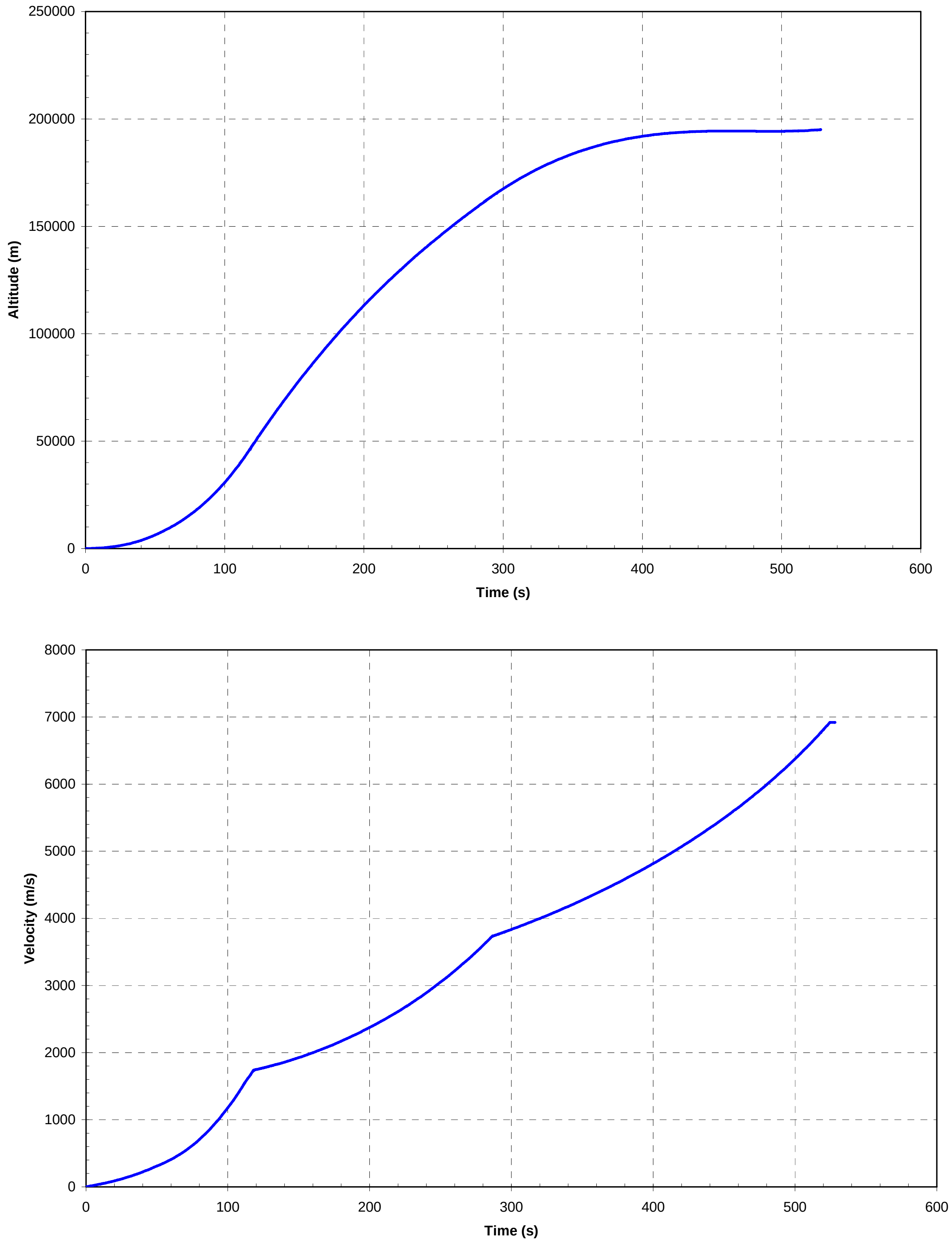


Figure 2.3 – Altitude and relative velocity during the ascent profile of the first three stages

### 2.3.2. Fregat upper stage flight profile

Following the third stage cut-off, the restartable Fregat upper stage delivers the payload or payloads to their final orbits. A typical Fregat flight profile is shown in Figure 2.4. This profile consists of the following events:

- Intermediate orbit ascent profile: after third stage separation, and Fregat injection in the parking orbit, Fregat burns are performed to transfer the payload to a wide variety of final orbits, providing the required plane changes and orbit raising. In this case, the Fregat ACS thrusters are operated 5 seconds after separation from the third stage followed 55 seconds later with the ignition of the main Fregat engine. Fregat burns are then performed to transfer the payload as described above.
- Direct injection profile: a single Fregat burn injects the payload to the final orbit.

Up to 20 burns may be provided by the Fregat to reach the final orbit or to deliver the payload to the different orbits.

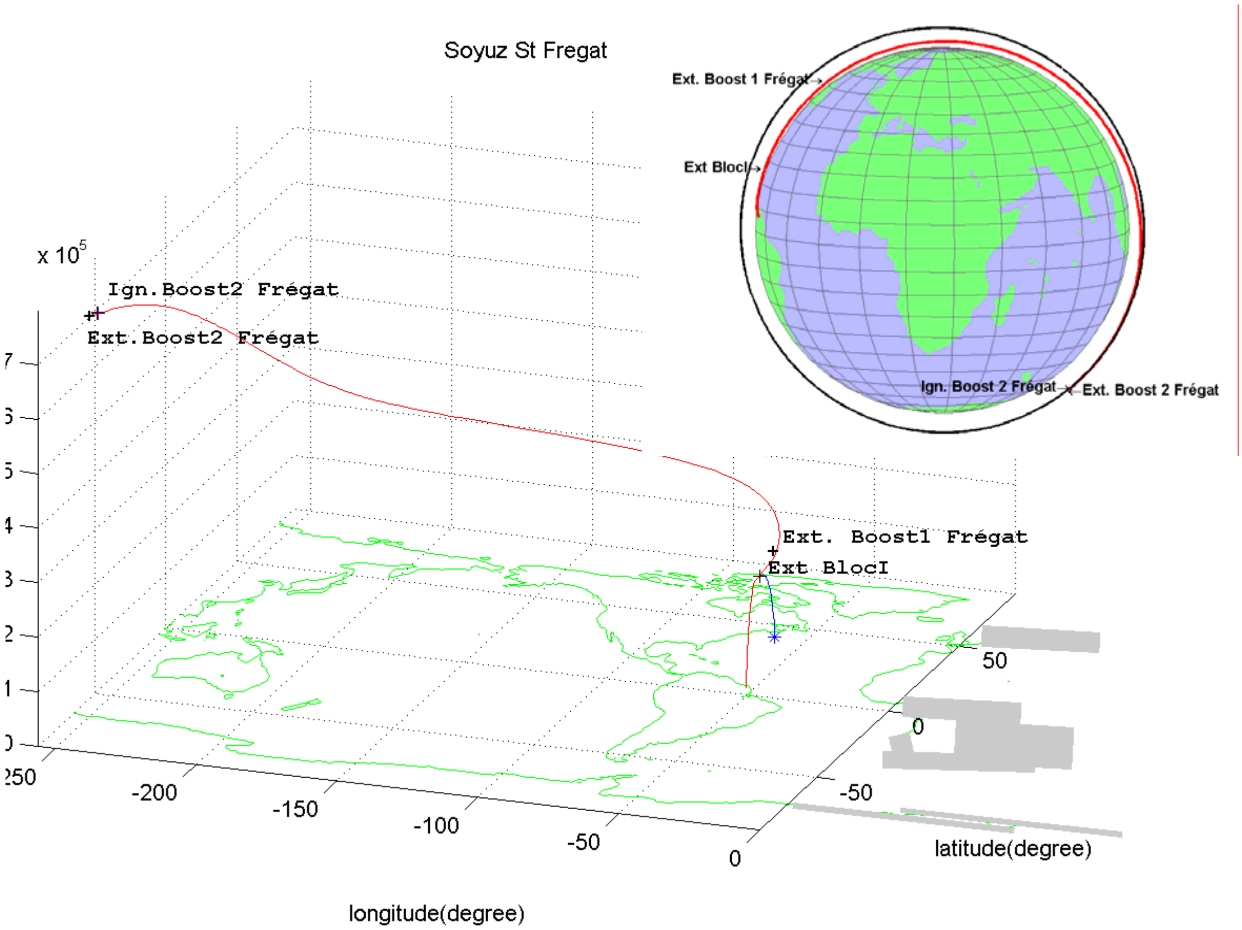


Figure 2.4 – Example of Fregat upper stage mission profile (SSO orbit)

### 2.3.3. Fregat deorbitation or orbit disposal manoeuvre

After spacecraft separation and following the time delay needed to provide a safe distance between the Fregat upper stage and the spacecraft, the Fregat typically conducts a deorbitation or orbit disposal manoeuvre. This manoeuvre is carried out by an additional burn of the Fregat's ACS thrusters or in some cases by the main engine. Parameters of the "safe" orbit or entry into the earth's atmosphere will be chosen in accordance with international laws pertaining to space debris and will be coordinated with the user during mission analysis.

## 2.4. General performance data

### 2.4.1. Geostationary transfer orbit missions

#### 2.4.1.1. Standard Geostationary Transfer Orbit (GTO)

The geostationary satellites will benefit of the advantageous location of the Guiana Space Centre: its low latitude minimizes the satellite on-board propellant needed to reach the equatorial plane, providing additional lifetime.

The Soyuz mission consists in a three stages sub-orbital ascent and two Fregat burns leading to the injection into the GTO with osculating parameters at separation resulting in a $\Delta$V requirement on the satellite's propulsion system of approximately 1500 m/s:

| | | |
|---|---|---|
| Inclination, | I | = 7 deg. |
| Alttude of perigee, | $Z_p$ | = 250 km |
| Altitude of apogee, | $Z_a$ | = 35 786 km |
| Argument of perigee, | $\omega$ | = 178 deg |

Notes: Injection is defined as the end of upper stage thrust decay.

$Z_a$ is equivalent to true altitude at first apogee

The longitude of the first descending node is usually located around TBD deg West.

The Soyuz performance for this orbit with the RD-0110 or the RD-0124 3rd stage engine is:

**2730 kg and 3060 kg** respectively.

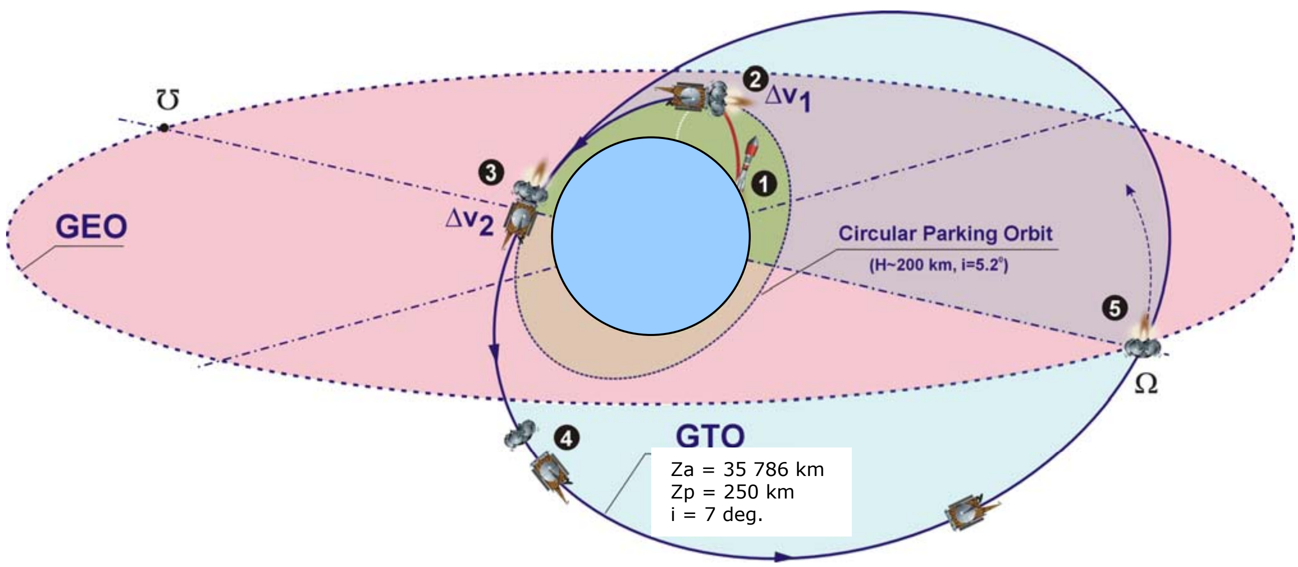


Figure 2.5 – Standard GTO mission profile

### 2.4.1.2. Super and sub Geostationary Transfer Orbits

**Refer as well to Chap. 2.4.1.4**

The Soyuz mission profile can be adapted to satellites which total mass exceeds or is lower than the standard GTO LV's performance. It is applicable to satellites with liquid propulsion systems giving the possibility of several transfer burns to the GEO and which tank capacity allows the optimal use of the performance gain.

**Satellite mass lower than standard GTO LV performance:**

In that case the LV injects the satellite on an orbit with a higher apogee or a lower inclination requiring a lower velocity increment (ΔV) to reach the GEO. The satellite propellant gain can be used for lifetime extension or for an increase of the satellite dry-mass.

**Satellite mass higher than standard GTO LV performance:**

In that case the LV injects the satellite on an orbit with a lower apogee. The satellite realizes then a Perigee Velocity Augmentation maneuver using proper extra propellant.

The overall propulsion budget of the mission translates in a benefit for the spacecraft in terms of lifetime (for a given dry-mass) or in terms of dry mass (for a given lifetime) compared to the standard GTO injection profile.

TO BE ISSUED LATER

Figure 2.6 – Typical Super/Sub GTO performance as function of altitude of apogee.

### 2.4.1.3. Direct GeoSynchronous equatorial Orbit

Refer as well to Chap. 2.4.1.4

The Soyuz launch vehicle can inject a payload directly into Geo-Synchronous equatorial Orbit (GSO) by means of a three-burn Fregat mission. The injection scheme is the same as the one presented for the GTO mission, but with a final Fregat burn to change the inclination and circularize on the GSO.

The maximum Launch Vehicle performance in GSO is 1340 kg.

### 2.4.1.4. Super GTO and GSO injection

While the injection orbit for a single launch on Soyuz can be optimized with a higher apogee, and even, technically speaking, with a launch directly on the GSO, **the standard injection remains on the standard GTO** that provides the customer the full benefit of the compatibility of the two launch systems: Ariane and Soyuz.

### 2.4.2. Circular orbits

The typical Soyuz mission includes a three stage sub-orbital ascent and two Fregat burns as follows:

- A first burn for transfer to the intermediate elliptical orbit with an altitude of apogee equal to the target value; and
- A second Fregat burn for orbit circularization.

#### 2.4.2.1. SSO and Polar orbits

The earth observation, meteorological and scientific satellites will benefit of the Soyuz capability to delivery them directly into the sun synchronous orbits (SSO) or polar circular orbits.

The performance on a 660km SSO is 4450 kg (TBC) with the Soyuz 2-1a. The performance on a 660km SSO is 4900 kg (TBC) with the Soyuz 2-1b.

LV performance data for SSOs are presented in Figure 2.7 as a function of altitude.

Performance data for polar orbits are presented in Figure 2.8.

#### 2.4.2.2. Other circular orbits

Almost all orbit inclinations can be accessed from the CSG.

Supply missions to the International Space Station, satellite constellations deployment and scientific missions can also be performed by Soyuz from the CSG.

LV performance data for circular orbit missions with inclination 56 and 63 deg, and altitudes between 400 and 25,000 km are presented in Figure 2.9.

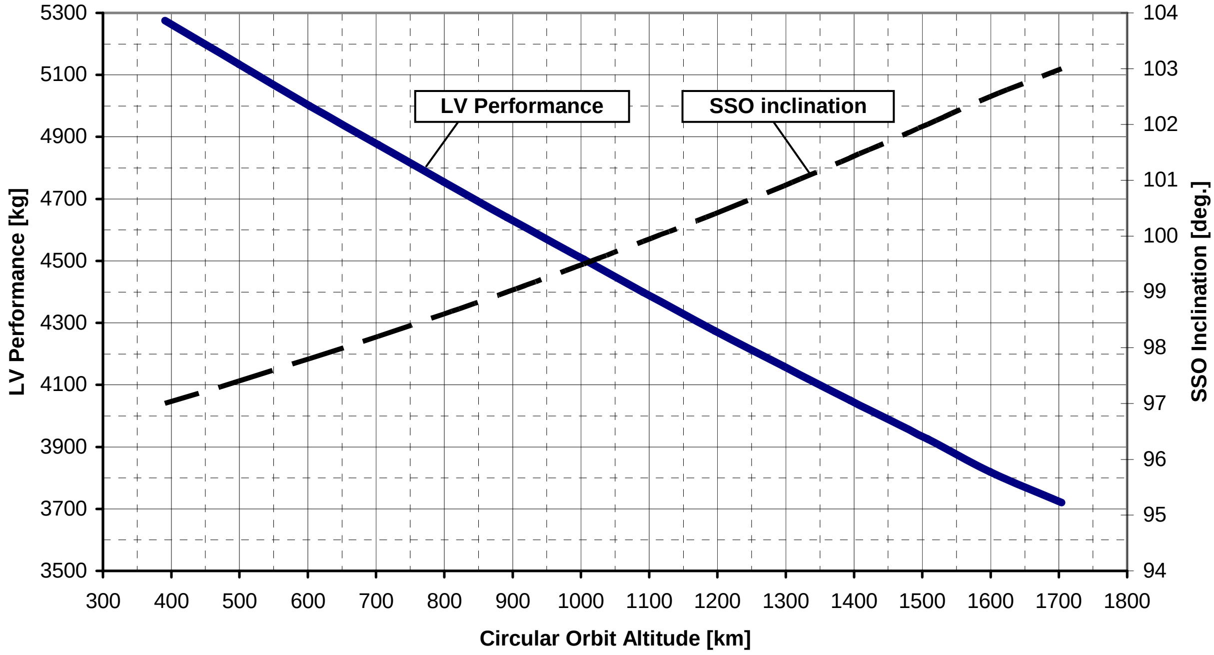


Figure 2.7 – Preliminary LV performance for SSO orbits to be considered for trade-off studies only. For precise data, please contact Arianespace.

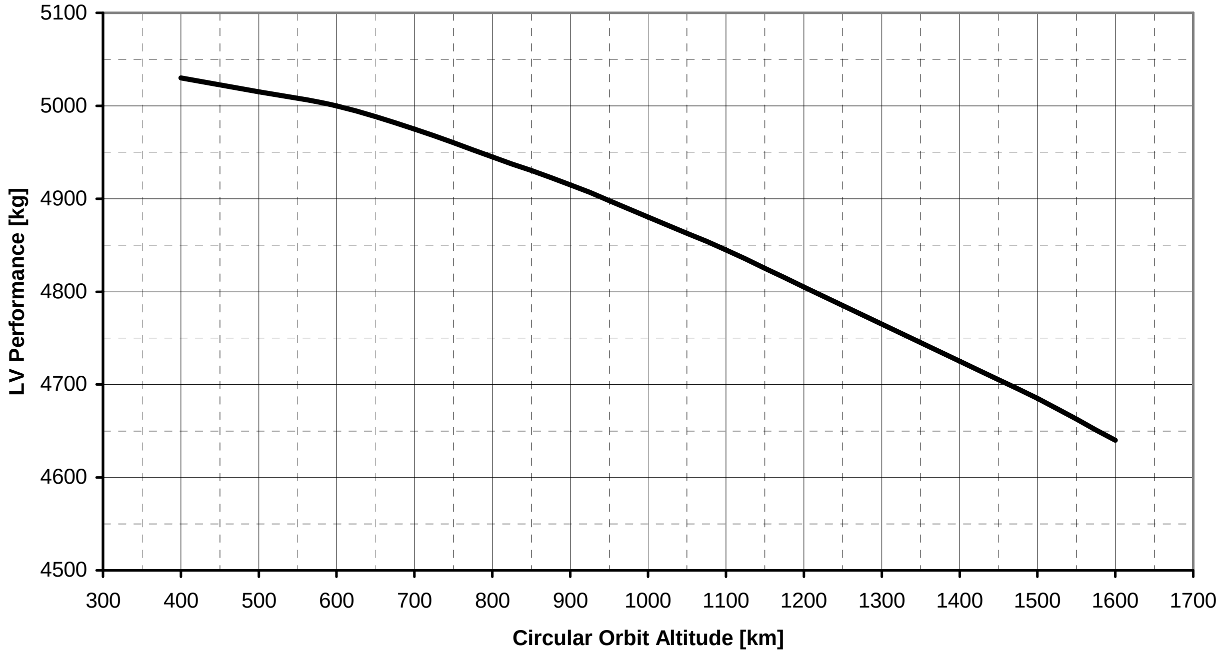


Figure 2.8 – LV performance for polar orbits, to be considered for trade-off studies only. For precise data, please contact Arianespace

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Figure 2.9 – LV performance for circular orbits. Orbit inclination 56 deg.

### 2.4.3. Elliptical orbit missions

The Fregat restartable capability offers a great flexibility to servicing a wide range of elliptical orbits.

A typical Soyuz mission includes the three stages sub-orbital ascent and two or three Fregat burns, as follows:

- A first burn to transfer to an initial parking orbit, followed by a coast phase up to a point corresponding to the required argument of perigee of the targeted elliptical orbit (in case of sub-orbital mission);
- A second Fregat burn to transfer to an intermediate elliptical orbit with an altitude of apogee equal to the target value; and
- A third Fregat burn to raise the perigee to the required value.

In some cases, when a lower altitude of perigee is required, the mission will be reduced to two Fregat burns.

LV performance data for a 51.8 degree inclination and a perigee altitude of 200 km are presented in Figure 2.10 and Figure 2.11.

Specific mission profiles for elliptical orbits can be analyzed on a mission-peculiar basis.

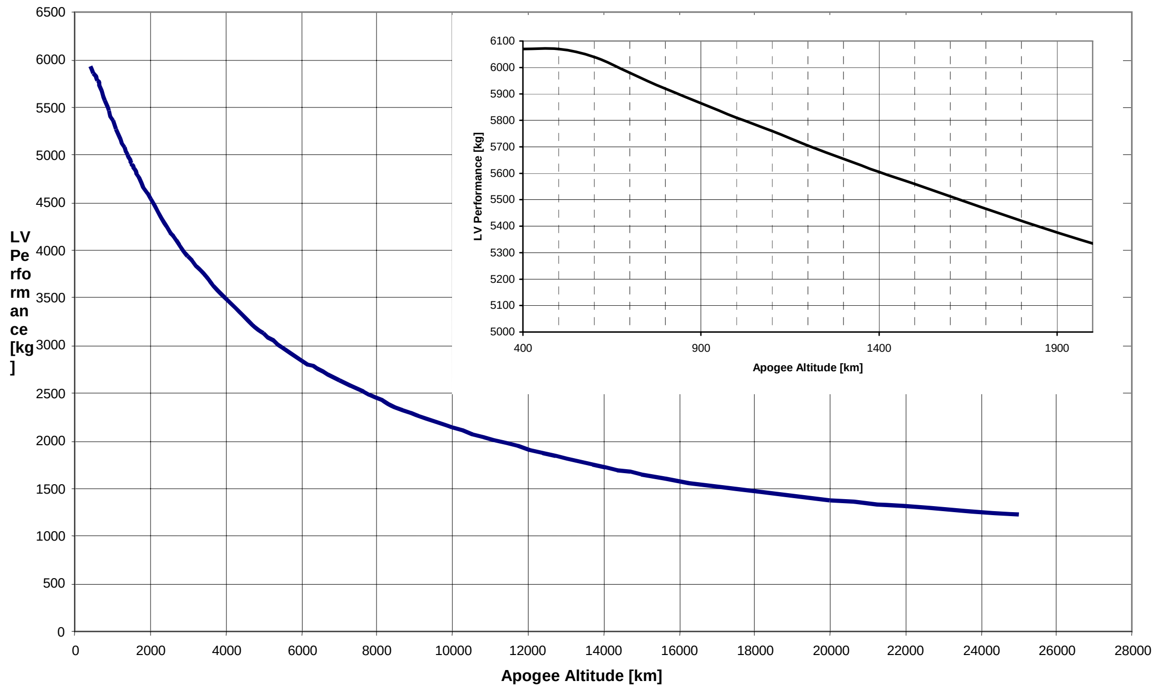



Figure 2.10 - LV performance data for elliptical orbit with 51.8 deg inclination and a perigee altitude of 200 km. for apogee up to 25 000 km.

TO BE ISSUED LATER

Figure 2.11 - LV performance data for elliptical orbit with 51.8 deg inclination and a perigee altitude of 200 km. for apogee up to 400 000 km.

### 2.4.4. Earth escape missions

The performance data for earth escape missions is presented in Figure 2.12 as a function of the parameter $C^3$ (square of velocity at infinity).

For more accurate data, users should contact Arianespace for a performance estimate and a mission-adapted profile.

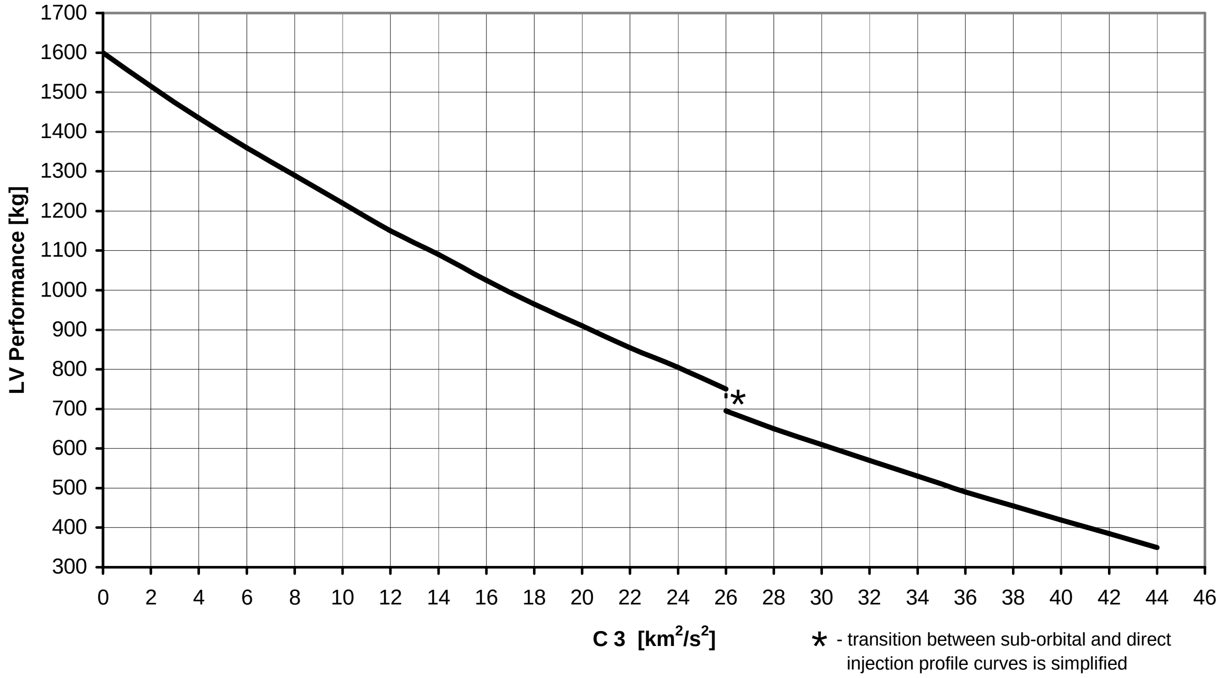



Figure 2.12 – preliminary LV performance data for escape missions (TBC). For accurate data, please contact Arianespace

## 2.5. Injection accuracy

The accuracy of the four-stage Soyuz is determined mainly by the performance of the Fregat upper stage. Conservative accuracy data depending on type of the mission are presented in Table 2.1. Mission-specific injection accuracy will be calculated as part of the mission analysis.

Table 2.1 - Injection Accuracy (± 1σ)

| Mission – Altitude (km) / Orbital Parameters | Circular Orbit | | GTO | Super/Sub GTO |
|---|---|---|---|---|
| | 1000 | 20,000 | 35,785 x 250 | TBD |
| Semi-major axis (km) | 3.3 | 20 | 23.3 | TBD |
| Altitude of apogee (km) | - | - | 40 | TBD |
| Altitude of perigee (km) | - | - | 6.6 | TBD |
| Eccentricity | $6.6\ 10^{-4}$ | $3.3\ 10^{-4}$ | $2.6\ 10^{-4}$ | TBD |
| Inclination (deg) | 0.033 | 0.04 | 0.05 | TBD |
| Argument of perigee (deg) | - | - | 0.083 | TBD |
| RAAN (deg) | 0.05 | 0.083 | 0.083 | TBD |

Note: Though the accuracy of some injection parameters for Super GTO is less than that for GTO, the required S/C fuel amount for final orbit correction is approximately the same in both cases.

## 2.6. Mission duration

Mission duration from lift-off until separation of the spacecraft on the final orbit depends on the selected mission profile, specified orbital parameters, injection accuracy, and the ground station visibility conditions at spacecraft separation.

Typically, critical mission events such as payload separation are carried out within the visibility of LV ground stations. This allows for the receipt of near-real-time information on relevant flight events, orbital parameters on-board estimation, and separation conditions.

The typical durations of various missions (without the visibility constraint of spacecraft separation) are presented in Table 2.2. Actual mission duration will be determined as part of the detailed mission analysis, taking into account ground station availability and visibility.

Table 2.2- Typical Mission Duration (up to Spacecraft Separation) TBD

| Mission | Altitude (km) | Mission Duration (hh:mm) |
|---|---|---|
| GTO and Super/Sub GTO | 20,000 - 120,000 | 00:20 - 01:30 |
| Circular orbit | SSO 800<br>10,000<br>20,000 | 01:00 - 01:30<br>02:00 - 02:30<br>03:10 - 03:40 |
| Elliptical orbit | 1,000 x 39,464 | 01:00 - 02:30 |
| Earth escape mission* | | 01:15 - 01:45 |

Note: * - Mission duration depends on declination requirements.

## 2.7. Launch windows

The Soyuz LV can be launched any day of the year, any time of the day respecting the specified lift-off time. The inaccuracy of any planned launch time, in a nominal mission scenario, is less than one second, taking into account all potential dispersions in the launch sequencing and system start/ignition processes.

The launch window is defined taking in to account the satellite mission requirements such as the orbit accuracy or the separation orbital position (requirements for the right ascension of the ascending node [RAAN]) and the respective ability of the launch vehicle to recover launch time error.

In case of shared (dual) launch, Arianespace will taken into account the launch windows of each co-passenger to define combined launch window.

In order to allow the possibility of several launch attempts and account for any weather or technical concern resolution a minimum launch window of 45 minutes is recommended.

The actual launch window of each mission and its impact on performance will be calculated as part of mission analysis activities.

## 2.8. Spacecraft orientation during the flight

During coast phases of the flight the Attitude Control Systems allow the launch vehicle to satisfy a variety of spacecraft orbital requirements, including thermal control maneuvers, sun-angle pointing constraints, and telemetry transmission maneuvers. On the contrary, the active parts of the mission like ascent boost phases and upper stage orbital burns and TM maneuvers will determine the attitude position of spacecraft. The best strategy to meet satellite and launch vehicle constraints will be defined with the Customer during the Mission Analysis process.

## 2.9. Separation conditions

After injection into orbit, the launch vehicle Attitude Control System is able to orient the upper composite to any desired attitude(s) and to perform separation(s) in various modes:

- 3-axis stabilization;
- longitudinal spin.

After completion of the separation(s) , the launch vehicle carries out a last manœuvre to avoid subsequent collision.

### 2.9.1. Orientation performance

The attitude at separation can be specified by the Customer in any direction in terms of :

- Fixed orientation during the entire launch window, or (TBC)
- Time variable orientation dependant on the sun position during the launch window,

For other specific satellite pointing, the Customer should contact Arianespace.

### 2.9.2. Separation mode and pointing accuracy

The actual pointing accuracy will result from the Mission Analysis.

The following values cover Soyuz compatible spacecrafts as long as their balancing characteristics are in accordance with para. 4.5.3. They are given as satellite kinematic conditions at the end of separation and assume the adapter and separation system are supplied by Arianespace.

In case the adapter is provided by the Satellite Authority, the Customer should contact Arianespace for launcher kinematic conditions just before separation.

Possible perturbations induced by spacecraft sloshing masses are not considered in the following values.

#### 2.9.2.1. Three-Axis stabilized mode

The 3-σ attitude accuracy for a three-axis stabilized mode are:

- geometrical axis depointing ≤ 1 deg
- angular tip-off rates along longitudinal axis ≤ 0.3 deg/s
- angular tip-off rates along transversal axis ≤ 0.3 deg/s

#### 2.9.2.2. Spin stabilized mode

The Fregat ACS can provide a roll rate around the upper composite longitudinal axis between TBD deg/s and 30 deg/s, clockwise or counterclockwise. Higher spin rates are possible but shall be specifically analyzed.

Although the spacecraft kinematic conditions just after separation are highly dependant on the actual spacecraft mass properties (including uncertainties), and the spin rate, the following values are typical results.

The 3-σ attitude accuracy for a 30 deg/sec spin mode are:

- Spin rate accuracy ≤ 1 deg/s
- Transverse angular tip-off rates ≤ 0.3 deg/s
- Depointing of kinetic momentum vector, half angle ≤ 1 deg
- Nutation, angle ≤ 10 deg.

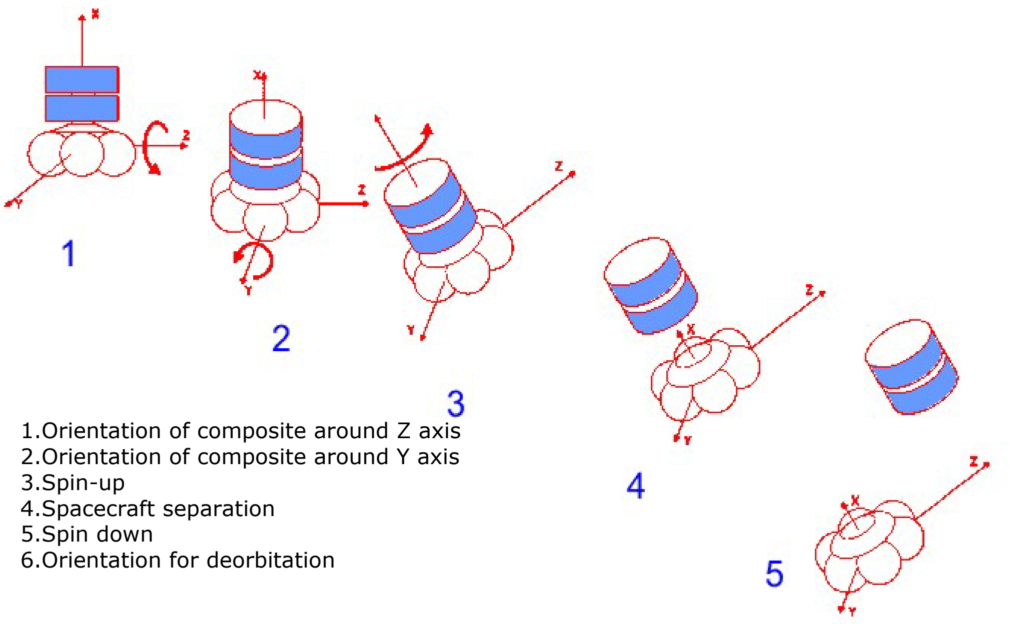



Figure 2.13 – Typical separation sequence.

### 2.9.2.3. Separation linear velocities and collision risk avoidance

The payload adapter's separation systems are designed to deliver a minimum relative velocity between spacecraft and upper stage ranging from 0.3 m/s to 1m/s.

For each mission, Arianespace will verify that the distances between orbiting bodies are adequate to avoid any risk of collision until the launcher final maneuver.
For this analysis, the Customer has to provide Arianespace with its orbit and attitude maneuver flight plan, otherwise the spacecraft is assumed to have a pure ballistic trajectory (i.e. no s/c maneuver occurs after separation).

After completion of the separation(s), the launch vehicle carries out a dedicated maneuver to avoid the subsequent collision or the satellite orbit contamination.

### 2.9.2.4. Multi-separation capabilities

The Soyuz LV is also able to perform multiple separations with mission peculiar payload dispensers or the internal dual launch carrying structure. A conceptual definition of this kind of dispenser is presented in Annex TBD, the dual launch carrying structure is defined in chapter 5. In this case the kinematics conditions presented above will be defined through the dedicated separation analysis.

For more information, please contact Arianespace.

## 1.2. European Space Transportation System

To meet all Customer's requirements and to provide the highest quality of services, Arianespace proposes to Customer a fleet of launch vehicles: Ariane, Soyuz and Vega. Thanks to their complementarities, they cover all commercial and governmental mission requirements, providing access to the different type of orbits from Low Earth Orbit to Geostationary Transfer Orbit and even to interplanetary one. This family approach provides Customers with a real flexibility to launch their spacecrafts and insure in a timely manner their planning for orbit delivery.

The Soyuz operation complements the Ariane 5 and Vega offer in the medium-weight payload class for low earth orbit, and provides additional flexibility in delivery of satellite up to 3 t to GTO orbit.

The decision to operate Soyuz from the Guyana Space Centre (CSG) was taken by the European Space Agency May 27, 2003 associated with a perspective of evolution of the European launcher sector for the 2010 timeframe. These decisions covered the continuity of the Ariane 5 launch service, the development and commercial availability of the Vega small launch vehicle from 2008 onwards, and the Soyuz commercial operations from the Guiana Space Centre, starting in 2008.

The exclusive exploitation of this launch vehicle family was entrusted to Arianespace – a unique launch services operator relying on the European and Russian space industry.

The Customer will appreciate the advantages and possibilities brought by the present synergy, using a unique high quality rated launch site, a common approach to the LV/spacecraft suitability and launch preparation, and the same quality standards for mission integration and management.

## 1.3. Arianespace launch services

Arianespace offers to its customers reliable and proven launch services that include:

- Exclusive marketing, sales and management of Ariane-5, Soyuz, and Vega operations;
- Mission management and support that covers all aspects of launch activities and preparation from contract signature through launch;
- Systems engineering support and analysis;
- Procurement, verification, and delivery of the launch vehicle and all associated hardware and equipment, including all adaptations required to meet customer requirements;
- Ground facilities and support (GRS) for customer activities at launch site;
- Combined operations at launch site, including launch vehicle and spacecraft integration and launch;
- Launcher telemetry and tracking ground station support and post-launch activities;
- Assistance and logistics support, which may include transportation and assistance with insurance, customs, and export licenses;
- Quality and safety assurance activities;
- Insurance and financing services on a case by case basis.

Arianespace provides the customer with a project oriented management system, based on a single point of contact (the Program Director) for all launch service activities, in order to simplify and streamline the process, adequate configuration control for the interface documents and hardware, transparence of the launch system to assess the mission progress and schedule control.

## 1.4. Soyuz launch vehicle family

### 1.4.1. History

The Soyuz is the most recent of a long line of Soyuz family vehicles that, taken together, are acknowledged to be the most frequently rockets launched in the world. Vehicles of this family, that launched both the first satellite (Sputnik, 1957) and the first man (Yuri Gagarin, 1961) into space, have been credited with more than 1700 launches to date. The three-stage version known as Soyuz, first introduced in 1966, has been launched more than 850 times. Due to their close technical similarity (same lower three stages), the Molniya and Soyuz vehicles are commonly combined together for reliability calculations. In the last 25 years they have completed a success rate of 98,1% over more than 950 launches. As the primary manned launch vehicle in Russia and the former Soviet Union, and as today one of the primary transport to the International Space Station, the Soyuz has benefited from these standards in both reliability and robustness. The addition of the flexible, restartable Fregat upper stage in 2000 allows the Soyuz launch vehicle to perform a full range of missions (LEO, SSO, MEO, GTO, GEO, and escape).

Table 1.1 shows a timeline of LV Soyuz development.

**Table 1.1 - Soyuz LV Family Evolution**

| | |
|---|---|
| 1957 – 1960 | R-7A / Sputnik (Two-stage missile used to launch the Sputnik payload - no longer in production) |
| 1958 – 1991 | Vostok (Three-stage LV with the block E as third stage - no longer in production) |
| 1960 – | Molniya* (Four-stage LV with the block I as third stage and block L or ML as upper stage) |
| 1963 – 1976 | Voskhod (Three-stage LV with the block I as third stage - no longer in production) |
| 1966 – 1976 | Soyuz (Voskhod upgrade for the launch of the Soyuz manned capsule - no longer in production) |
| 1973 – | Soyuz U (Unified LV for the replacement of Voskhod, Soyuz ) |
| 1982 – 1995 | Soyuz U2 (Soyuz-U upgrade for use of the improved fuel “Sintin” in the second stage - no longer in production) |
| 1999 | Introduction of Ikar upper stage for commercial missions (no longer in production) |
| 2000 | Introduction of Fregat upper stage |
| 2001 | Introduction of upgraded first and second stage engines, RD-107A and RD-108A |
| 2004/6 | Introduction of a digital control system, the ST fairing and the upgraded third stage engine, RD-0124 |

Note:

* Molniya launch vehicle is still operational and will be progressively replaced by the Soyuz with the Fregat upper stage.

The Soyuz is launched from the Baikonur Cosmodrome in Kazakhstan, from the Plesetsk Cosmodrome in the North of Russia and from the Guiana Space Centre in French Guiana to meet the needs of the commercial market and continuing to serve the needs of Russian government and other institutional and international programs.

Soyuz LVs continue to be mass-produced in Samara, Russia, by the Samara Space Center, whose facilities have been designed to accommodate the production of up to four LVs per month. As a result of the continued demand from the Russian government, International Space Station activity, and commercial orders, the Soyuz LV is in uninterrupted production at an average rate of 10 to 15 LVs per year with a capability to rapidly scale up to accommodate users' needs.

The Fregat upper stage production by NPO Lavochkine, Moscow, Russia is well suited with this production rate.

### 1.4.2. Vehicle Reliability

Table 1.2 shows the information on Soyuz reliability. Reliability figures are presented individually for the lower three stages of the vehicle and for the Fregat upper stage. This is primarily due to the large statistical database of flights with the lower three stages. To provide most relevant data to future missions, it was chosen to present reliability figures for the flights performed in the past 25 years. The figures presented include the "Soyuz" and "Molniya" flights, as these two configurations has a nearly identical lower three stages. Furthermore, since 1977, the "Soyuz" and "Molniya" configurations are the only vehicles of the Soyuz family to remain in production, replacing all previous versions.

**Table 1.2 - Flight Success Ratio**

| Component/Vehicle | Soyuz & Molniya | Fregat upper stage |
|---|---|---|
| Time frame | 1977 - 2005 | 2000 - 2005 |
| Number of Flights | 968 | 8 |
| Number of Failures | 19 | 0 |
| Flight Success Rate (%) | 98 | 100 |

Note:

The flight success rate is the overall ratio of successful flights over flight attempts. It takes into account all launch system failures, regardless of corrections or modifications.

Taken into account the design objectives and extensive qualification program, it is projected that the flight reliability of Soyuz with the new components of the launch vehicle such as the larger payload fairing, third stage engines and control system will not be affected.

## 1.5. Launch system description

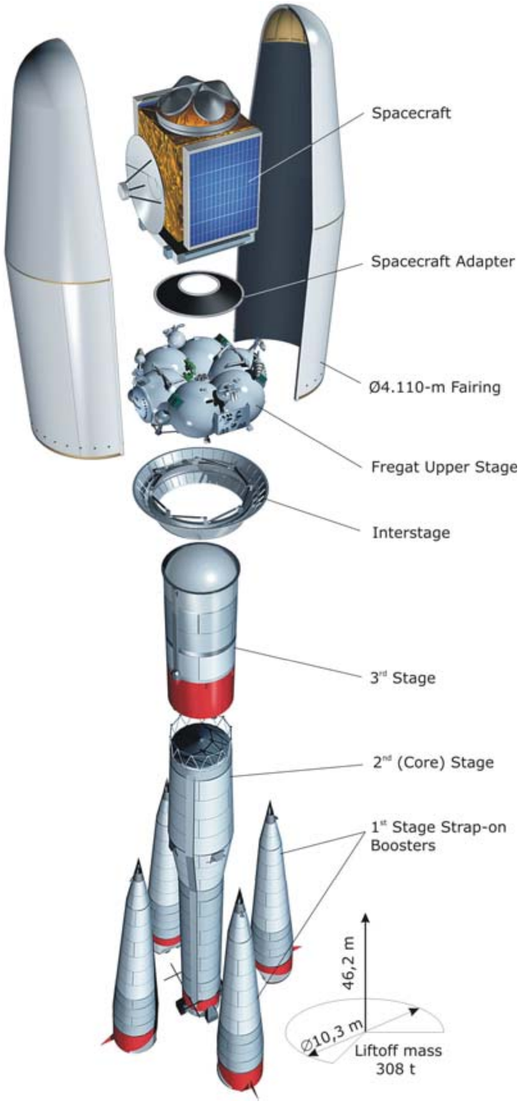
Arianespace offers a complete launch system including the vehicle, the launch facilities, and the associated services.

### 1.5.1. Launch vehicle general data

The Soyuz LV consists primarily of the following components:

- A lower composite consisting of four liquid-fueled boosters (first stage), a core (second) stage, and a third stage;
- A restartable Fregat upper stage;
- A payload fairing and interstage section; and
- A payload adapter/dispenser with separation system(s). Depending on the mission requirements, a variety of different adapters/dispensers may be used.

The Soyuz configuration used at CSG and corresponded vehicle data is shown in Figure 1.1 and outlined in the Annex 5.




## PAYLOAD FAIRINGS

| Fairing | ST | S |
|---|---|---|
| Diameter: | 4.110 m | 3.715 m |
| Length: | 11.433 m | 7.700 m |
| Mass: | 1700 kg | 1045 kg |
| Structure: | Two-half-shell carbon-fiber reinforced plastic | Two-half-shell aluminum skin-stringer |
| Separation | Mechanical locks/ pneumatic jack/pushers | Mechanical locks/Spring jack/pushers |
| **Interstage** | | |
| Mass: | 400 kg | 350 kg |
| Structure: | aluminum skin-stringer | Aluminum-skin stringer |

## PAYLOAD ADAPTERS

| Off-the-shelf devices: | | |
|---|---|---|
| | 1194SF | (110 kg); |
| | 937SF | (45 kg); |
| | 1666SF | (100 kg) |

## FREGAT UPPER STAGE

| | |
|---|---|
| **Size:** | 3.35-m diameter × 1.50-m height |
| **Inert mass:** | 950 kg |
| **Propellant:** | 5350-kg $N_2O_4$/UDMH |
| **Subsystems:** | |
| **Structure:** | Structurally stable aluminum alloy 6 spherical tanks/8 cross rods |
| **Propulsion** | S5.92 |
| **- Thrust** | Two mode thrust 19.85/14.00 kN - Vac |
| **- Isp** | Two mode thrust 331/316 s - Vac |
| **- Feed system** | Pump-fed, open cycle gas generator |
| **- Pressurization** | Ghe vaporization |
| **- Burn time / Restart** | Up to 900 s / up to 20 controled or depletion burn |
| **Attitude Control** | |
| **- pitch, yaw** | Main engine translation or eight 50-N hydrazine thrusters |
| **- roll** | Four 50-N hydrazine thrusters |
| **Avionics** | Inertial 3-axis platform, on-board computer, TM & RF systems, Power |
| **Stage separation:** | gas pressure locks/pushers |

| . | 1st STAGE (FOUR BOOSTERS) | 2nd STAGE (CORE) | 3rd STAGE | |
|---|---|---|---|---|
| **Size:** | 2.68-m diameter × 19.60-m length | 2.95-m diameter × 27.10-m length | 2.66-m diameter × 6.70-m length | |
| **Gross/Dry mass:** | 44 413 kg / 3 784 kg | 99 765 kg / 6 545 kg | 27 755 kg / 2 355 kg | |
| **Propellant:** | 27 900-kg LOX<br>11 260-kg Kerosene | 63 800-kg LOX<br>26 300-kg Kerosene | 17 800-kg LOX<br>7 600 kg Kerosene | |
| **Subsystems:** | | | | |
| **Structure** | Pressure stabilized aluminium alloy tanks with intertanks skin structure | Pressure stabilized aluminum alloy tanks with intertanks skin structure | Pressure stabilized aluminum alloy tanks with intertanks and rear skin structure | |
| **Propulsion** | RD-107A 4-chambers engine, | RD-108A 4-chambers engine, | RD-0110 4-chamber engine (Soyuz 2-1a) | RD-0124 4-chamber engine (Soyuz 2-1b) |
| **- Thrust** | 838.5 kN – SL; 1021.3 kN –Vac | 792.5 kN – SL; 990.2 kN –Vac | 297.9 kN (Vac) | 297.9 kN (Vac) |
| **- Isp** | 262 s – SL; 319 s –Vac | 255 s – SL; 319 s –Vac | 325 s -Vac | 359 s (Vac) |
| **- Feed system** | pump-fed by hydrogen peroxide ($H_2O_2$) gas generator | pump-fed by hydrogen peroxide ($H_2O_2$) gas generator | Pump-fed gas generator, generator's gas blow down through verniers | Multi-stage pump-fed close cycle gas generator |
| **- Pressurization** | Liquid nitrogen ($N_2$)vaporization | Liquid nitrogen ($N_2$) vaporization | Oxygen vaporization/generator gases | Helium vaporization |
| **- Burn time / Restart** | 118 s / No – two level thrust throttling | 286 s / No – one level thrust throttling | 250 s / No | 270 s / No |
| **Attitude Control** | Two 35-kN vernier thrusters and one aerofin | Four 35-kN vernier thrusters | Four 6-kN vernier thrusters | Each chambers gimbaling in one axis |
| **Avionics** | Input/Output units, TM, power | Input/Output units, TM, power | Centralized control system: inertial 3-axis platform, on-board computer, TM & RF system, power | |
| **Stage separation:** | Pyronuts/pushers/reaction nozzle | Pyronuts and 3rd stage engine ignition | | |

**Figure 1.1 – LV property data**

### 1.5.2. European spaceport and CSG Facilities

The launch preparation and launch are carried out from the Guiana Space Centre (CSG) – European spaceport operational since 1968 in French Guiana. The spaceport accommodates Soyuz, Ariane-5 and Vega separated launch facilities (ELS, ELA and ELV respectively) with common Payload Preparation Complex EPCU and launch support services.

The CSG is governed under an agreement between France and the European Space Agency that was recently extended to cover Soyuz and Vega installations. The day to day life of CSG is managed by French National Agency (Centre National d'Etude Spatiales – CNES) on behalf of the European Space Agency. CNES provides all needed range support, requested by Arianespace, for satellite and launch vehicle preparation and launch.

The CSG provides state-of–the-art Payload Preparation Facilities (Ensemble de Preparation Charge Utile – EPCU) recognized as a high quality standard in space industry. The facilities are capable to process several satellites of different customers in the same time, thanks to large cleanrooms and supporting infrastructures. Designed for Ariane-5 dual launch capability and high launch rate, the EPCU capacity is sufficient to be shared by the Customers of all three launch vehicles.

The satellite/launch vehicle integration and launch are carried out from launch sites dedicated for Ariane, Soyuz or Vega.

The Soyuz Launch Site (Ensemble de Lancement Soyuz – ELS) is located some 10 km North of the existing Ariane 5 launch facilities and provides the same quality of services for payload.

The moderate climate, the regular air and sea connection, accessible local transportation, and excellent accommodation facilities as for business and for recreation– all that devoted to User's team and invest to the success of the launch mission.

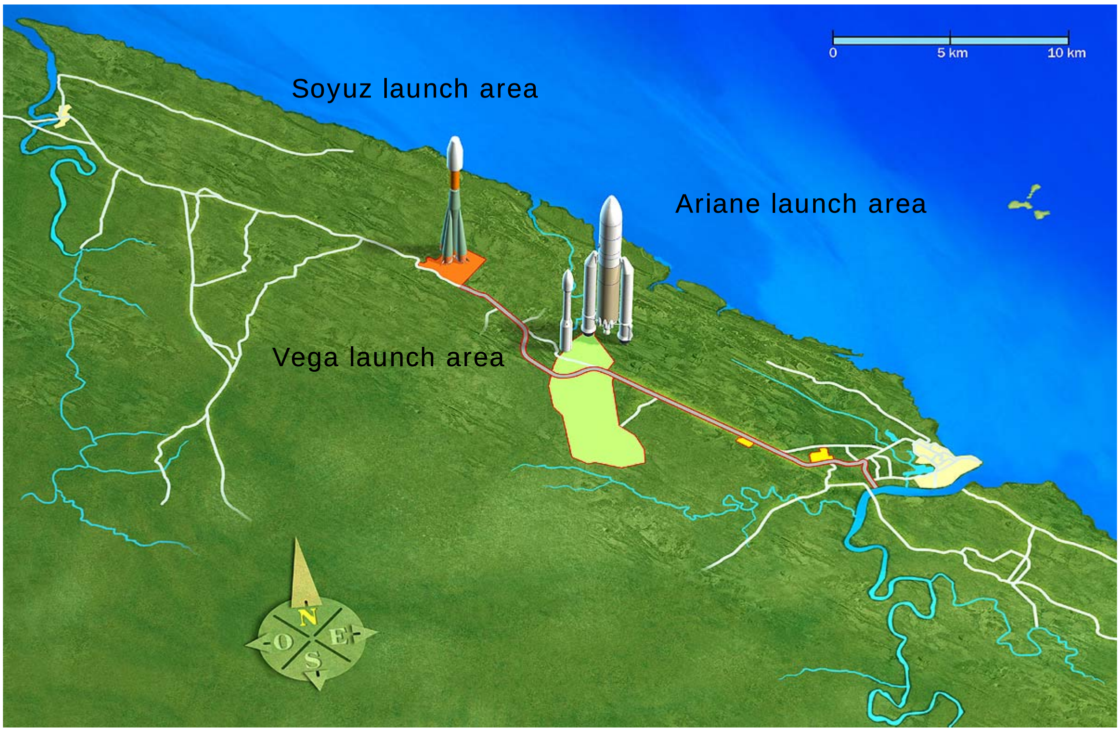
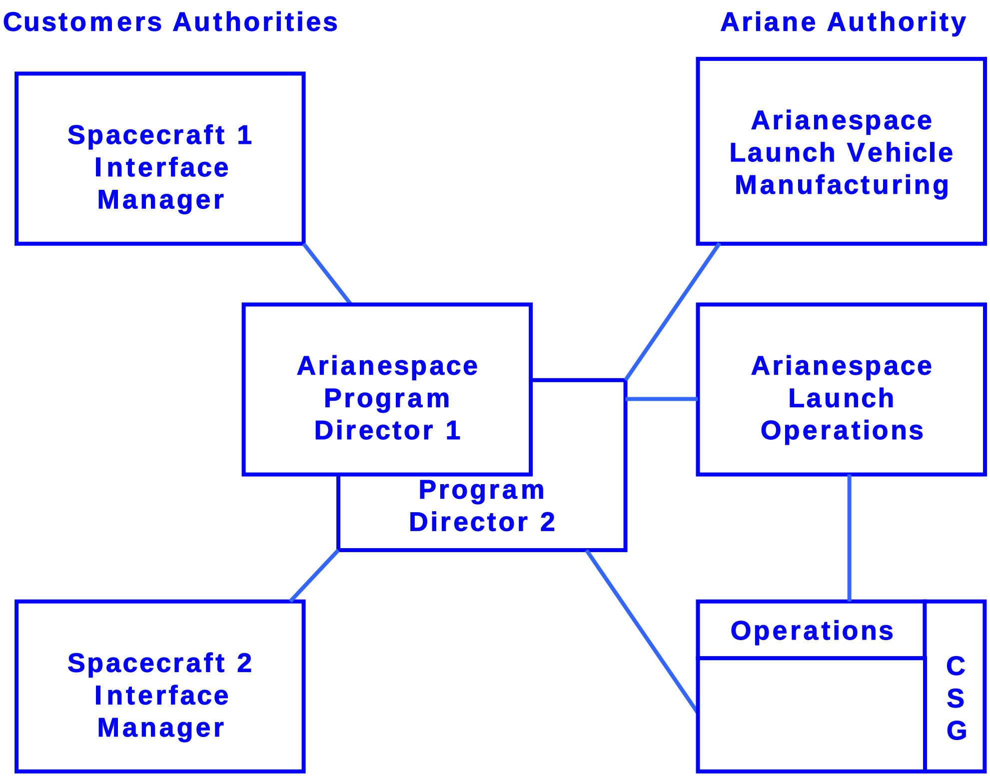



Figure 1.2 – CSG overview

### 1.5.3. Launch service organization

Arianespace is organized to offer a Launch Service based on a continuous interchange of information between a Spacecraft Interface Manager (Customer), and the Arianespace Program Director (Arianespace) who are appointed at the time of the launch contract signature. As from that date, the Ariane Program Director is responsible for the execution of the Launch Service Contract. For a given launch, therefore, there can be one or two Spacecraft Interface Manager(s) and one or two Arianespace Program Directors, depending on whether the launch is a single or dual one with different customers.

For the preparation and execution of the Guiana operations, the Arianespace launch team is managed by a specially assigned Mission Director who will work directly with the Customer's operational team.




Principle of Customers/Arianespace relationship (dual launch)

## 1.6. Corporate organization

### 1.6.1. Arianespace

Arianespace is a French joint stock company ("Societe Anonyme") which was incorporated on March 26th 1980 as the first commercial space transportation company.

In order to meet the market needs, Arianespace has established a worldwide presence: in Europe, with headquarter located at Evry near Paris, France; in North America with Arianespace Inc., its subsidiary in Washington D.C., and in the Pacific Region, with its representative offices in Tokyo (Japan) and Singapore.

Arianespace is the international leader in commercial launch services, and today holds an important part of the world market for satellites launched to the geostationary transfer orbit (GTO). From its creation in 1980, Arianespace has successfully performed over 160 launches and signed contracts for more than 250 payloads with some 55 operators/customers.

Arianespace provides each customer a true end-to-end service, from manufacture of the launch vehicle to mission preparations at the Guiana Space Centre and successful in-orbit delivery of payloads for a broad range of mission.

Arianespace as a unique commercial operator oversees the marketing and sales, production and operation from CSG of Ariane, Soyuz and Vega launch vehicles.

Arianespace continues the Soyuz commercial operations started in 1999 in Baikonur by Starsem having as of January 2006 a record of 15 successful launches.


Figure 1.3 – The Arianespace worldwide presence

### 1.6.2. Partners

Arianespace is backed by shareholders that represent the best technical, financial, and political resources of the 12 European countries participating in the Ariane and Vega programs:

- 22 Aerospace engineering companies from 10 European countries
- 1 Space agency

Building on the experience gained by its daughter company Starsem since 1996 with the Soyuz launches from Baikonur, the Soyuz operation from CSG results of a transfer of the Soyuz commercial concession to Arianespace, that will allow to improve the services provided on the commercial market.

Starsem is a 50/50 joint venture between Russian and European partners that draws on some of the worldwide best–known names in the space industry:

- The European Aeronautic Defense and Space Company – EADS
- Arianespace
- The Russian Federal Space Agency
- The Samara Space Center TsSKB-Progress

Starsem board consisting of representative of the three leading companies and space agency still covers the strategic decisions and common policy with regard to the commercial operation of Soyuz providing production and institutional support.

### 1.6.3. European Space transportation system organization

Arianespace benefits from a simplified procurement organization that relies on a prime supplier for each launch vehicle. The prime supplier backed by his industrial organization is in charge of production, integration, and launch preparation of the launch vehicle.

The prime suppliers for Ariane and Vega launch vehicle are respectively EADS LV and European Launch Vehicle (ELV). The prime supplier for the Soyuz launch vehicle is the Russian Federal Space Agency with SSC TsSKB-Progress as the Soyuz LV Authority, and NPO Lavotchkine as the provider of the Fregat upper stage.

Ariane, Soyuz and Vega launch operations are managed by Arianespace with the participation of the prime suppliers and range support from CNES CSG.

**The Soyuz operational team is based on SSC TsSKB-Progress, NPO L and KB OM representatives who are responsible for Soyuz LV preparation.**

Figure 1.4 shows the launch vehicle procurement organization.

To illustrate the industrial experience concentrated behind the Soyuz prime supplier, the Figure 1.5 shows second level subcontractors and their responsibilities.

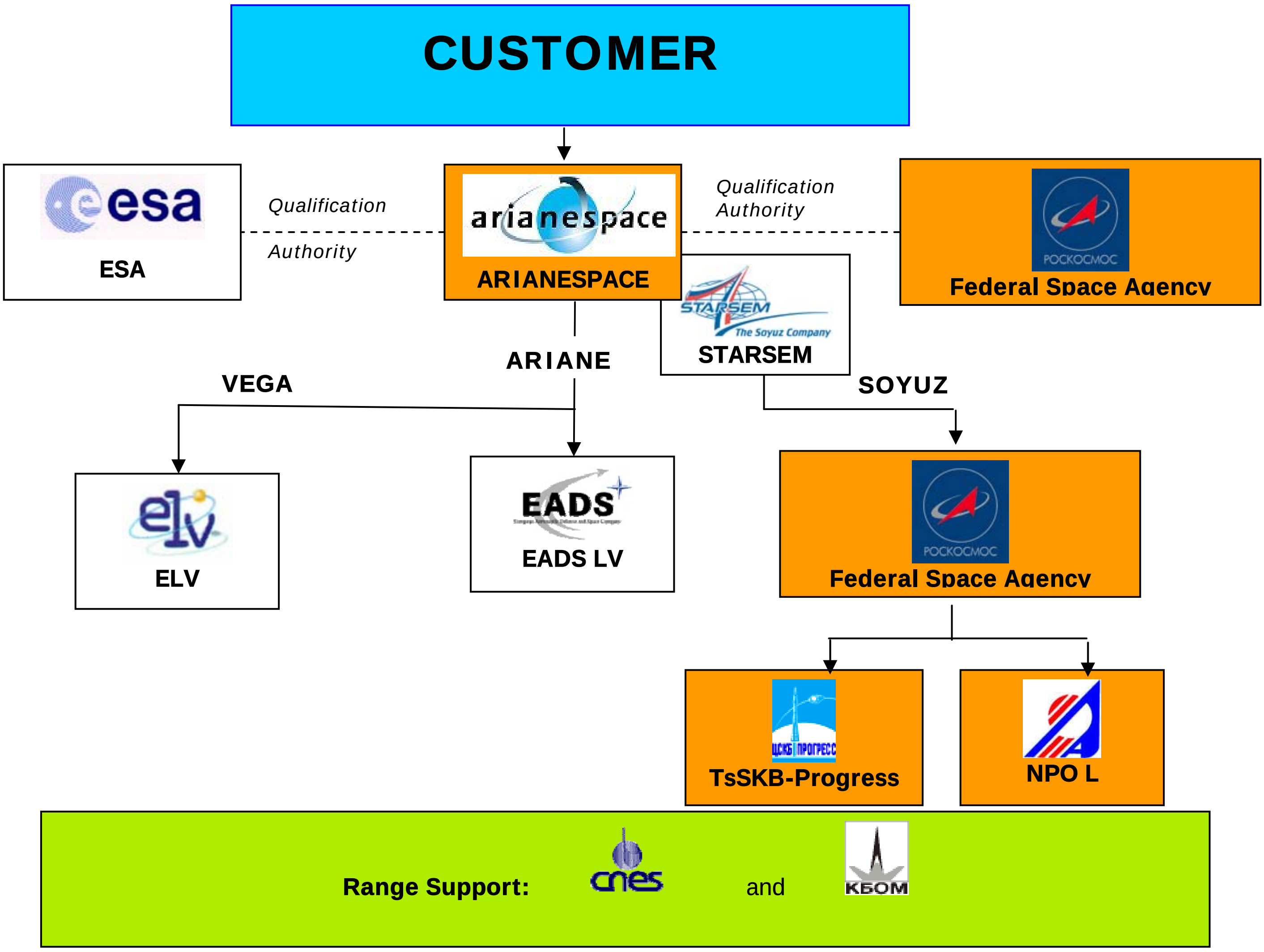



Figure 1.4 – The launch vehicle procurement organization

### 1.6.4. Main suppliers

#### 1.6.4.1. Russian Federal Space Agency

The Agency (FSA) represents the Russian federal executive authority that defines the Russian Federation's national policy in the field of space research and exploration. The agency also performs interdisciplinary coordination of national scientific and application space programs. It was created in February 1992 by a decree issued by the President of the Russian Federation.

FSA's responsibilities include: development and implementation of Russian national space policy; acting as governmental customer in the development of scientific and application space systems, facilities and equipment; establishing international cooperation and collaboration in space research, and organization/coordination of commercial space programs.

Operations under FSA responsibility include more than 400 aeronautic and space companies and organizations.

#### 1.6.4.2. The Samara Space Centre "TsSKB-Progress"

The Samara Space Center "TsSKB-Progress" was created in 1996 by combining the TsSKB Central Samara Design Bureau and the "Progress" production plant.

The Samara Space Center is one of the world leaders in the design of launchers, spacecraft and related systems. Its history goes back to the start of the space program in 1959 when a branch of the Moscow OKB-1 design bureau was established in the city of Kuibyshev (now known as Samara).

The Center developed a family of launch vehicles derived from the OKB-1's R-7 intercontinental ballistic missile. Approximately 10 versions were developed, including Sputnik (which carried the first man-made satellite into orbit), Vostok (used for the initial manned space flight), Molniya, and Soyuz.

In addition to years of experience building launch vehicles, TsSKB-Progress has also built numerous earth observation and scientific satellites.

#### 1.6.4.3. NPO Lavotchkine

NPO Lavotchkine was founded in 1937 as an aircraft manufacturer and, is one of the industry leaders in the development and implementation of interplanetary, astrophysical and earth monitoring projects such as :

- National programs: Luna, Mars, Venera, Bankir
- International programs: VEGA, Phobos, IRS-1, Granat, Mars-96, Interbol, Klaster
- Advanced programs : Spektr, Phobos-Grunt, Solnyechniy Zond, and others.

NPO Lavotchkine adapts, produces and is the technical authority for the Fregat upper stage. NPO Lavotchkin is also the technical authority for the assembled upper composite.

#### 1.6.4.4 KB OM

V.P. Barmin Design Bureau for General Engineering, was founded in 1941. KBOM specialises in the design and operation of launch facilities, space rocket ground infrastructure and in orbit processing equipment.

KB-OM is in charge of the development of the Russian systems for the Soyuz launch zone at the CSG.

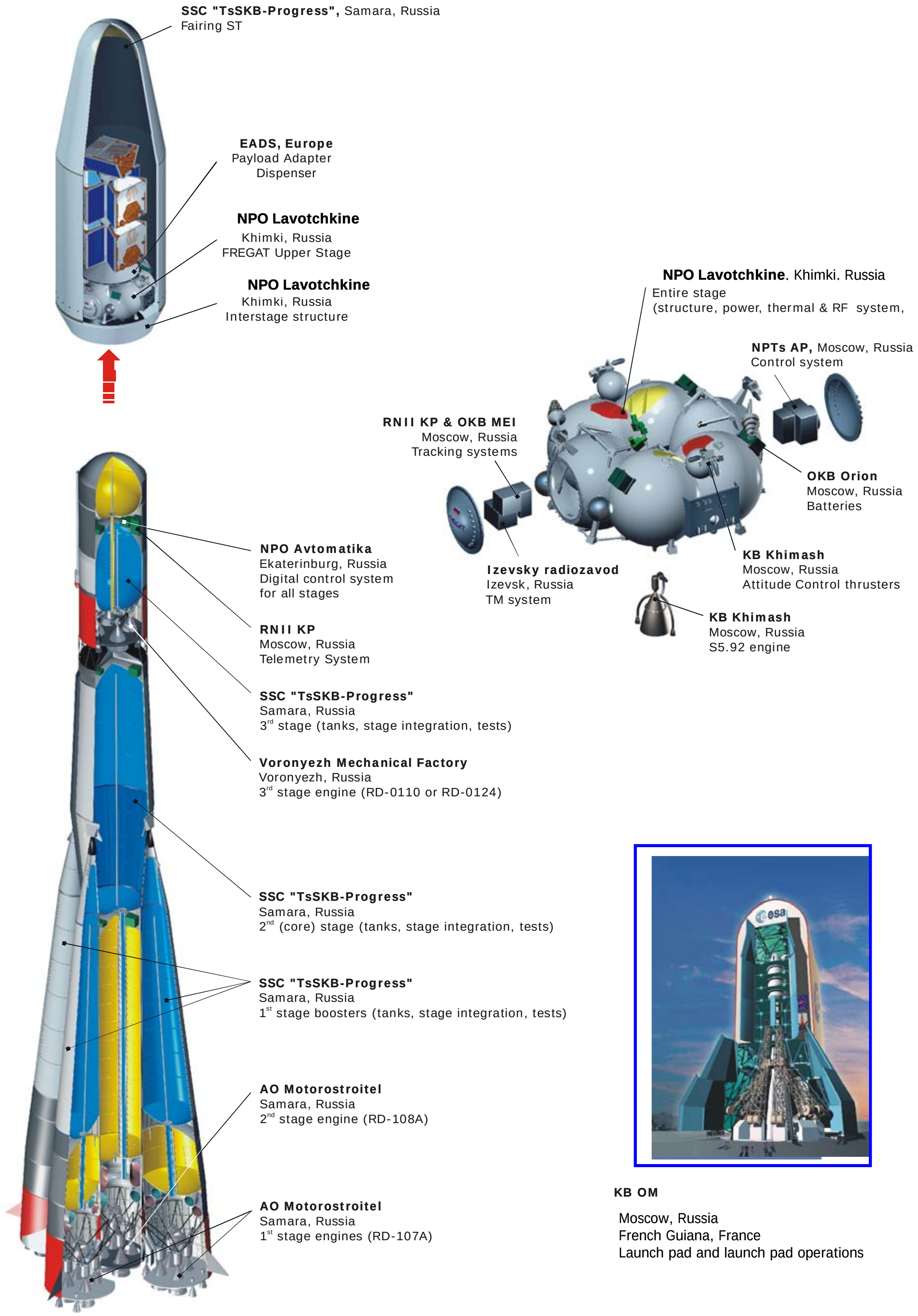



Figure 1.5 – The Soyuz subcontractors

# ENVIRONMENTAL CONDITIONS Chapter 3

## 3.1. General

During the preparation for launch at the CSG and then during the flight, the spacecraft is exposed to a variety of mechanical, thermal, and electromagnetic environments. This chapter provides a description of the environment that the spacecraft is intended to withstand.

All environmental data given in the following paragraphs should be considered as limit loads, applying to the spacecraft. The related probability of these figures not being exceeded is 99 %.

Without special notice all environmental data are defined at the spacecraft base, i.e. at the adapter/spacecraft interface.

The following sections present the environment for the two configurations Soyuz 2-1a and Soyuz 2-1b. It is further noted that the introduction of the RD-0124 engine on the Soyuz 2-1b configuration is not expected to measurably affect either the quasi-static loads or the sine-vibration levels since its thrust is identical to that of the RD-0110 engine, and moreover, a sequenced shut-down profile is implemented to reduce the transient loads at the end of the third stage flight.

## 3.2. Mechanical environment

### 3.2.1. Steady state acceleration

#### 3.2.1.1. On ground

The flight steady state accelerations described hereafter cover the load to which the spacecraft is exposed during ground preparation.

#### 3.2.1.2. In flight

During flight, the spacecraft is subjected to static and dynamic loads. Such excitations may be of aerodynamic origin (e.g., wind, gusts, or buffeting at transonic velocity) or due to the propulsion systems (e.g., longitudinal acceleration, thrust buildup or tail-off transients, or structure-propulsion coupling, etc.).

Figure 3.1 shows a typical longitudinal static acceleration-time history for the LV during its ascent flight. The highest longitudinal acceleration occurs just before the first-stage cutoff and does not exceed 4.3 g.

The highest lateral static acceleration may be up to 0.4 g at maximum dynamic pressure and takes into account the effect of wind and gust encountered in this phase.

The accelerations produced during Fregat flight are negligible and enveloped by the precedent events.

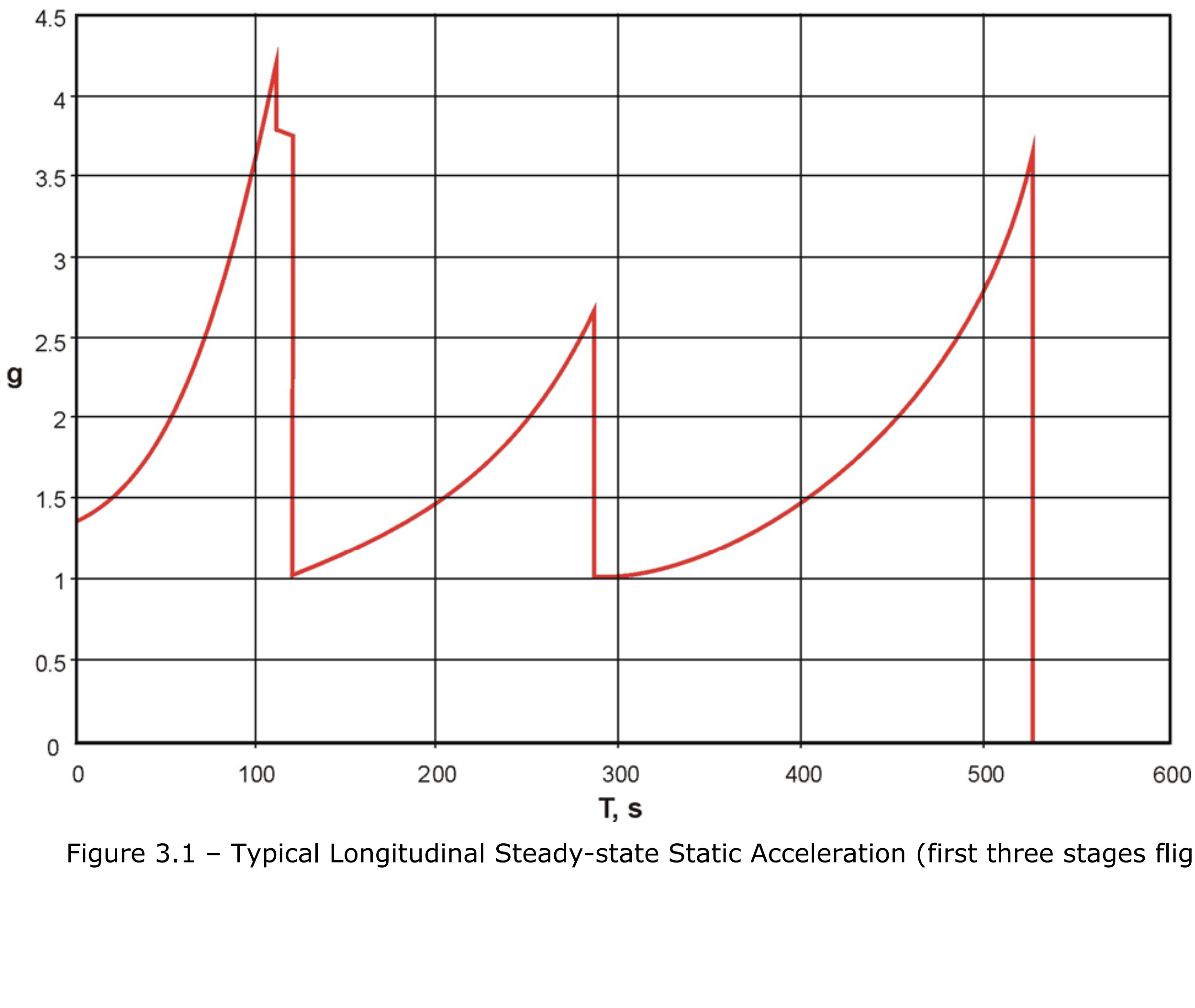



Figure 3.1 – Typical Longitudinal Steady-state Static Acceleration (first three stages flight)

### 3.2.2. Sine-equivalent dynamics

Sinusoidal excitations affect the LV during its powered flight (mainly the atmospheric flight), as well as during some of the transient phases.

The envelope of the sinusoidal (or sine-equivalent) vibration levels at the spacecraft base does not exceed the values given in Table 3.1.

The sinusoidal excitation above 40 Hz is insignificant.

Table 3.1 - Sine Excitation at Spacecraft Base

| Direction | Longitudinal | | | Lateral | | |
|---|---|---|---|---|---|---|
| Frequency Band (Hz) | 5 – 10 | 10 – 30 | 30 – 40 | 1 – 5 | 5 – 30 | 30 – 40 |
| Sine Amplitude (g) | 0.5 | 1.0 | 0.6 | 0.3 | 0.8 | 0.6 |

### 3.2.3. Random vibration

Random vibrations at the spacecraft base are generated by propulsion system operation and by the adjacent structure's vibro-acoustic response. Maximum excitation levels are obtained during the first-stage flight. Acceleration power spectral density (PSD) and root mean square vibration levels ($G_{RMS}$) are given in Table 3.2 along each of three axes. The random vibrations must be taken into account for equipment dimensioning in the 40 – 100 Hz frequency range, considering that at higher frequency it is covered by acoustic loads.

Table 3.2 – The maximum flight levels of random vibrations at Spacecraft Base

<table>
<tr><td rowspan="3">Event</td><td colspan="6">Frequency Band (Hz)</td><td rowspan="3">$G_{RMS}$ (g)</td><td rowspan="3">Duration of application (s)</td></tr>
<tr><td>20 – 50</td><td>50-100</td><td>100-200</td><td>200-500</td><td>500-1000</td><td>1000-2000</td></tr>
<tr><td colspan="6">PSD, Power Spectral Density(1) (g²/Hz)</td></tr>
<tr><td>1st stage flight</td><td>0.0050</td><td>0.0050<br>0.0100</td><td>0.0100<br>0.0250</td><td>0.0250</td><td>0.0250<br>0.0100</td><td>0.0100<br>0.0050</td><td>4.94</td><td>120</td></tr>
<tr><td>2nd stage and 3rd stage flight</td><td>0.0025</td><td>0.0025<br>0.0050</td><td>0.0050<br>0.0100</td><td>0.0100</td><td>0.0100<br>0.0050</td><td>0.0050<br>0.0025</td><td>3.31</td><td>480</td></tr>
<tr><td>FREGAT flight</td><td>0,0020</td><td>0,0020</td><td>0,0020</td><td>0,0020</td><td>0,0020<br>0,0010</td><td>0,0010</td><td>1,63</td><td>875</td></tr>
</table>

Note: (1) - Changes of the Power Spectral Density in frequency sub-ranges is linear, when a logarithmic scale is used for both frequency and Power Spectral Density.

### 3.2.4. Acoustic vibration

#### 3.2.4.1. On Ground

The noise level generated by the venting system does not exceed 94 dB.

#### 3.2.4.2. In Flight

Acoustic pressure fluctuations under the fairing are generated by engine operation (plume impingement on the pad during liftoff) and by unsteady aerodynamic phenomena during atmospheric flight (i.e., shock waves and turbulence inside the boundary layer), which are transmitted through the upper composite structures. Apart from liftoff and transonic flight, acoustic levels are substantially lower than the values indicated hereafter.

The envelope spectrum of the noise induced inside the fairing during flight is shown in Table 3.3. It corresponds to a space-averaged level within the volume allocated to the spacecraft stack, as defined in Chapter 5. The acoustic spectrum defined below covers excitations produced by random vibration at the spacecraft base for frequency band above 100 Hz.

It is assessed that the sound field under the fairing is diffuse.

Table 3.3 - Acoustic Noise Spectrum under the Fairing

| Octave Center Frequency (Hz) | Flight Limit Level (dB) (reference: 0 dB = $2 \times 10^{-5}$ Pa) |
|---|---|
| | ST-Type Fairing |
| 31.5 | 125 |
| 63 | 132 |
| 125 | 134 |
| 250 | 136 |
| 500 | 134 |
| 1000 | 125 |
| 2000 | 121 |
| OASPL (20 – 2828 Hz) | 141 |

Note: OASPL – Overall Acoustic Sound Pressure Level

This maximum environment is applied during a period of approximately 60 seconds: 15 seconds for lift-off and 45 seconds for atmospheric flight.

### 3.2.5. Shocks

The spacecraft is subject to shock primarily during stage separations, fairing jettisoning, and actual spacecraft separation.

The envelope acceleration shock response spectrum (SRS) at the spacecraft base (computed with a Q-factor of 10) is presented in Table 3.4, Table 3.5 and Figure 3.12. These levels are applied simultaneously in axial and radial directions.

For customers wishing to use their own adapter the acceptable envelope at the launch vehicle interface will be provided on a peculiar base.

Table 3.4 - Shock Response Spectra at Stage Separations and Fairing Jettisoning

| Flight Event | Frequency (Hz) | |
|---|---|---|
| | 100 – 1000 | 1000 – 5000 |
| | SRS, Shock Response Spectra (Q = 10) (g) | |
| Fairing separation, upper-stage separation | 15 – 350 | 350 |

Table 3.5 - Shock Response Spectra for off-the-shelf Clampband Separation Systems

| Spacecraft Adapter Interface Diameter | Band Tension kN | Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 100 | 600 | 800 | 1500 | 2000 | 5550 | 8000 | 10000 |
| | | SRS, Shock Response Spectra (Q = 10) (g) | | | | | | | |
| Ø 937 | ≤ 18.3 | 20 | | | 2000 | 2000 | 2000 | 2000 | 2000 |
| Ø 937 (type B) | ≤ 27.7 | 20 | | | | 3200 | 4147 | 4550 | 4550 |
| Ø 1194 | ≤ 28.2 | 20 | 1700 | | | 5000 | 5000 | 5000 | 5000 |
| Ø 1666 | ≤ 32 | 20 | 1800 | | 3500 | 3500 | 3500 | 3500 | 3500 |

TO BE ISSUED LATER

Figure 3.2 - Envelope acceleration shock response spectrum (SRS) at the spacecraft base

### 3.2.6. Static pressure under the fairing

#### 3.2.6.1. On Ground

After encapsulation, the air velocity around the spacecraft due to the ventilation system is lower than 5 m/sec (value experienced in front of the air inlet). The velocity may locally exceed this value; contact Arianespace for specific concern.

#### 3.2.6.2. In Flight

The payload compartment is vented during the ascent phase through one-way vent doors insuring a low depressurization rate of the fairing compartment.

The static pressure evolution under the fairing is shown in Figure 3.3. The depressurization rate does not exceed 2,0 kPa/s (20 mbar/s) for a sustained length of time. Locally at the time of maximum dynamic pressure, at ~ 50s, there is a short period of about 2 seconds when the depressurization rate can reach 3,5 kPa/s (35 mbar/s)).

The difference between the pressure under fairing and free-stream external static pressures, at the moment of the fairing jettisoning, is lower than 0,2 kPa (2 mbar).

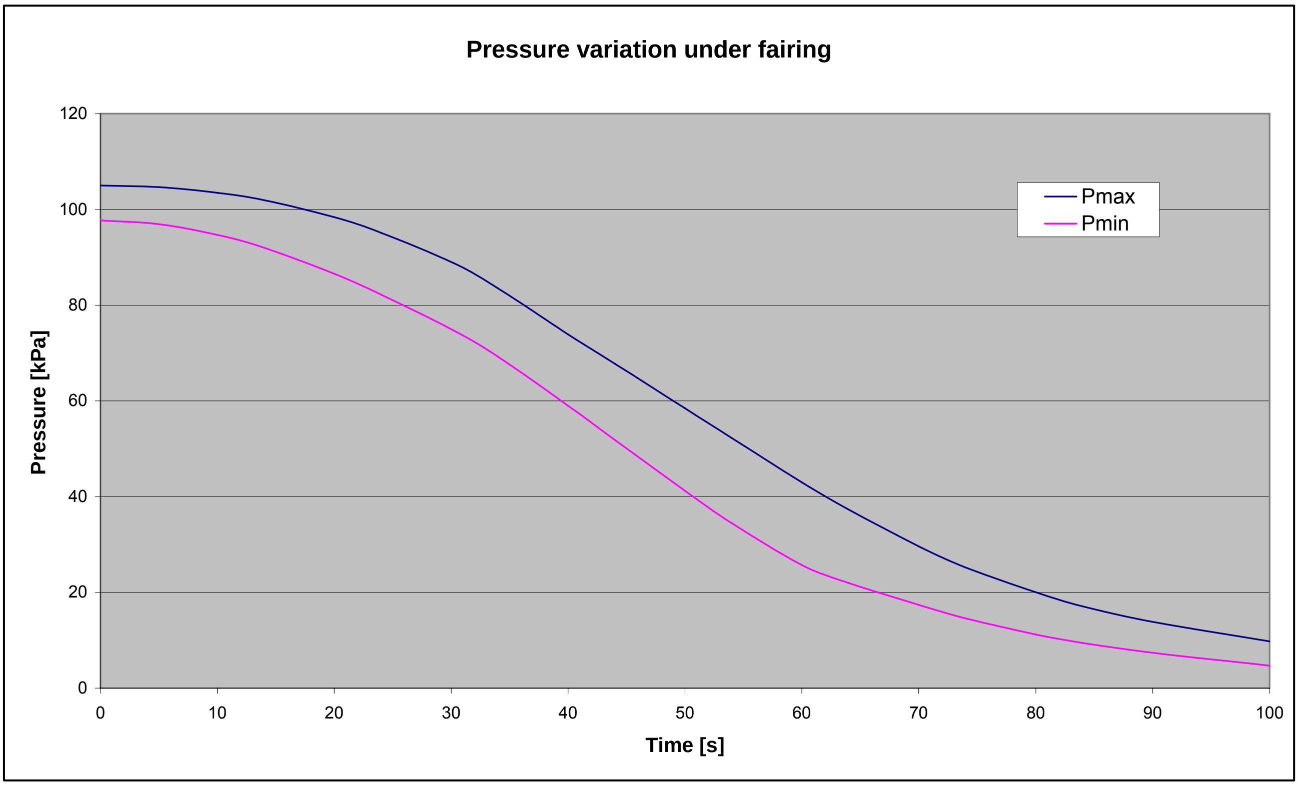



Figure 3.3 - Typical pressure variation under the fairing

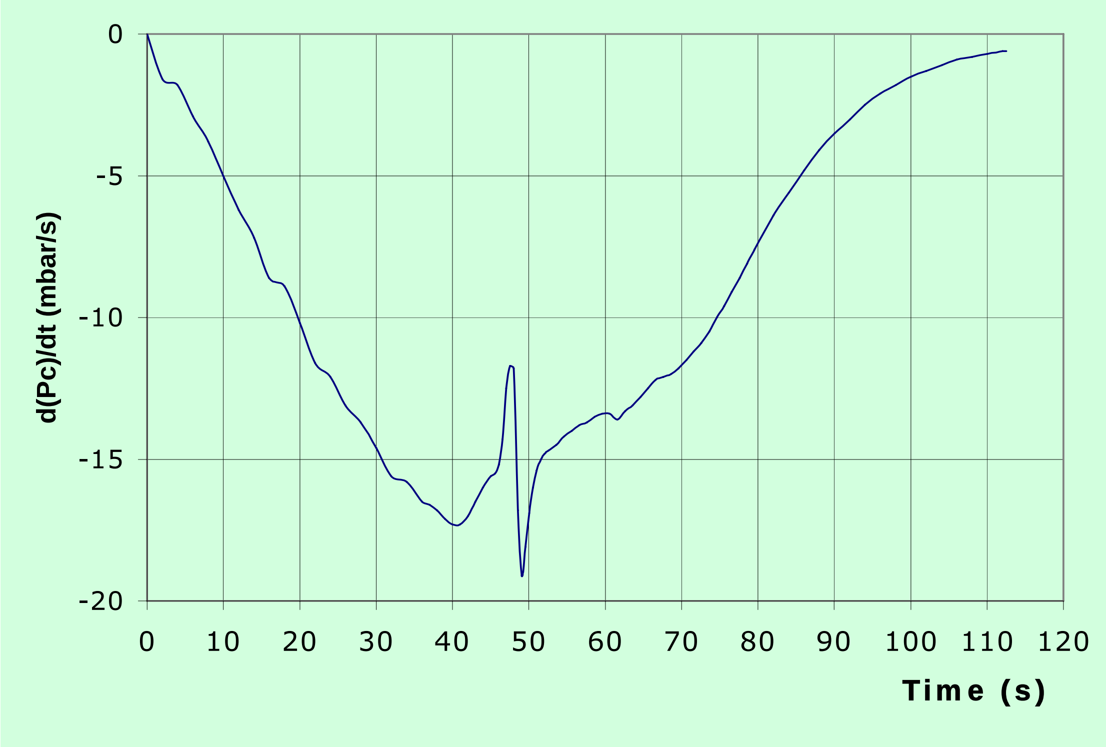



Figure 3.4 – Typical depressurization rate under fairing

## 3.3. Thermal environment

### 3.3.1. Introduction

The thermal environment provided during spacecraft preparation and launch has to be considered at following phases:

- Ground operations:
    - The spacecraft preparation within the CSG facilities;
    - The upper composite and launch vehicle operations with spacecraft encapsulated inside the fairing
- Flight
    - Before fairing jettisoning;
    - After fairing jettisoning

### 3.3.2. Ground operations

The environment that the spacecraft experiences both during its preparation and once it is encapsulated under the fairing is controlled in terms of temperature, relative humidity, cleanliness, and contamination.

#### 3.3.2.1. CSG Facility Environments

The typical thermal environment within the most of air-conditioned CSG facilities is kept around 23°C ± 2°C for temperature and 55% ± 5% for relative humidity.

More detailed values for each specific hall and buildings are presented in the EPCU User's Manual and in Chapter 6.

#### 3.3.2.2. Thermal conditions under the fairing

During the encapsulation phase and once mated on the launch vehicle, the spacecraft is protected by an air-conditioning system provided by the ventilation through the pneumatic umbilicals: high flow rate (H), and through the launch vehicle for the last 45 minutes, when the gantry has been rolled away: low flow rate (L).See fig 3.5.

Table 3.6 - Air Conditioning under the Fairing

| Phase | Air-conditioning system | Temperature | Relative Humidity | Flow, $Nm^3/h$ | Duration |
|---|---|---|---|---|---|
| Operations in UCIF | UCIF air-conditioning system | 23 ± 1°C | 50%±5% | "ICE" system if necessary | 2 weeks max |
| Transfer from UCIF to Launch Pad | CARAVAN | 16°C | < 60% | 1500 | ~3 h |
| Upper composite hoisting and mating on the LV | | < 27°C | < 60% | No venting, overpressure. | 1 h |
| Launch preparation | "High mode" venting | Any value specified between 11°C and 25°C* Accuracy: ± 2°C | ≤ 20% | ≤2000 | 4 days |
| Final countdown | "Low mode" venting | Any value specified between 11°C and 25°C* Accuracy: ± 2°C | ≤ 20% | ≤ TBD | H0-2h00 min up to lift-off |
| Aborted launch | "Low mode" venting | Any value specified between 11°C and 25°C* Accuracy: ± 2°C | ≤ 20% | ≤ TBD | A few minutes after abort up to High flow mode reconnection (H0+4h00m) |

Note:

(*) - The air temperature before lift-off shall be agreed on a case-by-case basis in order to take into account the Fregat's constraints and the spacecraft's heat dissipation.

TO BE ISSUED LATER

Figure 3.5 – Configuration of the air-conditioning systems

### 3.3.3. Flight environment

#### 3.3.3.1. Thermal conditions before fairing jettisoning

The thermal flux density radiated by the fairing does not exceed 800 W/$m^2$ at any point. This figure does not take into account any effect induced by the spacecraft dissipated power.

#### 3.3.3.2. Aerothermal flux and thermal conditions after fairing jettisoning

The nominal time for jettisoning the fairing is determined in order not to exceed the aerothermal flux of 1135 W/$m^2$. This flux is calculated as a free molecular flow acting on a plane surface perpendicular to the velocity direction and based on the atmospheric model US 66, latitude 15° North.

Typically the aerothermal flux varies from 1135 W/$m^2$ to less than 200 W/$m^2$ within 20 seconds after the fairing jettisoning, as presented in Figure 3.6.

For dedicated launches, lower or higher flux exposures can be accommodated on request, as long as the necessary performance is maintained.

Solar radiation, albedo, and terrestrial infrared radiation and conductive exchange with LV must be added to this aerothermal flux. While calculating the incident flux on spacecraft, account must be taken of the altitude of the launch vehicle, its orientation, the position of the sun with respect to the launch vehicle, and the orientation of the considered spacecraft surfaces.

During daylight with long ballistic and/or coast phases the sun radiation has to be taken into account. In order to reduce the heat flux, the launcher can be spun up to TBD °/s.
A specific attitude with respect to the sun may also be used to reduce the heating during boosted (TBC) and/or coast phases. This will be studied on a case by case basis.

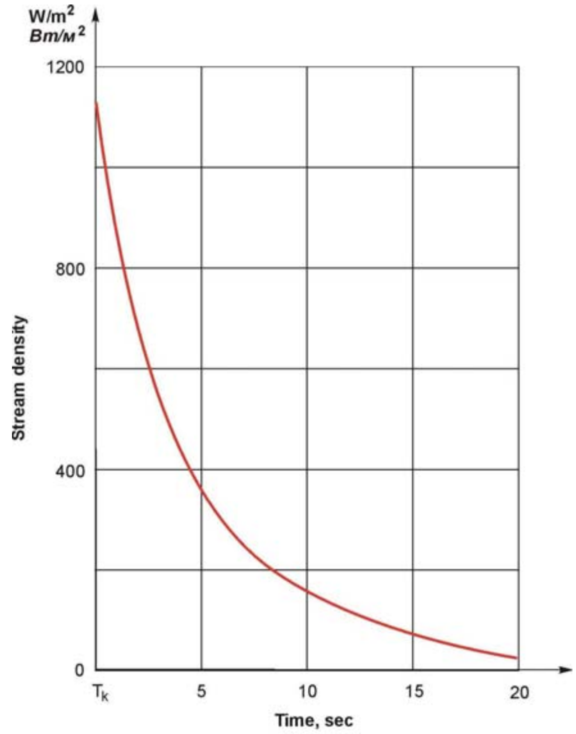



Figure 3.6 – Aerothermal Flux Decay after fairing jettisoning

### 3.3.3.3. Other thermal fluxes

#### *3.3.3.3.1. Thermal Flux Reflected from Separated Stages*

No thermal flux coming from separated stages need be considered.

#### *3.3.3.3.2. Thermal Flux Radiated from Fregat's Attitude Control System*

As the Fregat attitude control thrusters are located in the vicinity of the spacecraft, they may generate a heat flux that must be taken into account if sensitive equipment is located on the bottom surface of the spacecraft.

The heat flow (Q) distribution along the spacecraft bottom surface for one of the thrusters pair is given in Figure 3.7, where

r = the distance from the spacecraft longitudinal axis;

φ = the angle counted from the plane in the thrust direction where the simultaneously operating thrusters are located:

φ (A) = angle φ corresponding to the operation of the thrusters located in the I-III plane; and

φ (B) = angle φ corresponding to the operation of the thrusters located in the II-IV plane.

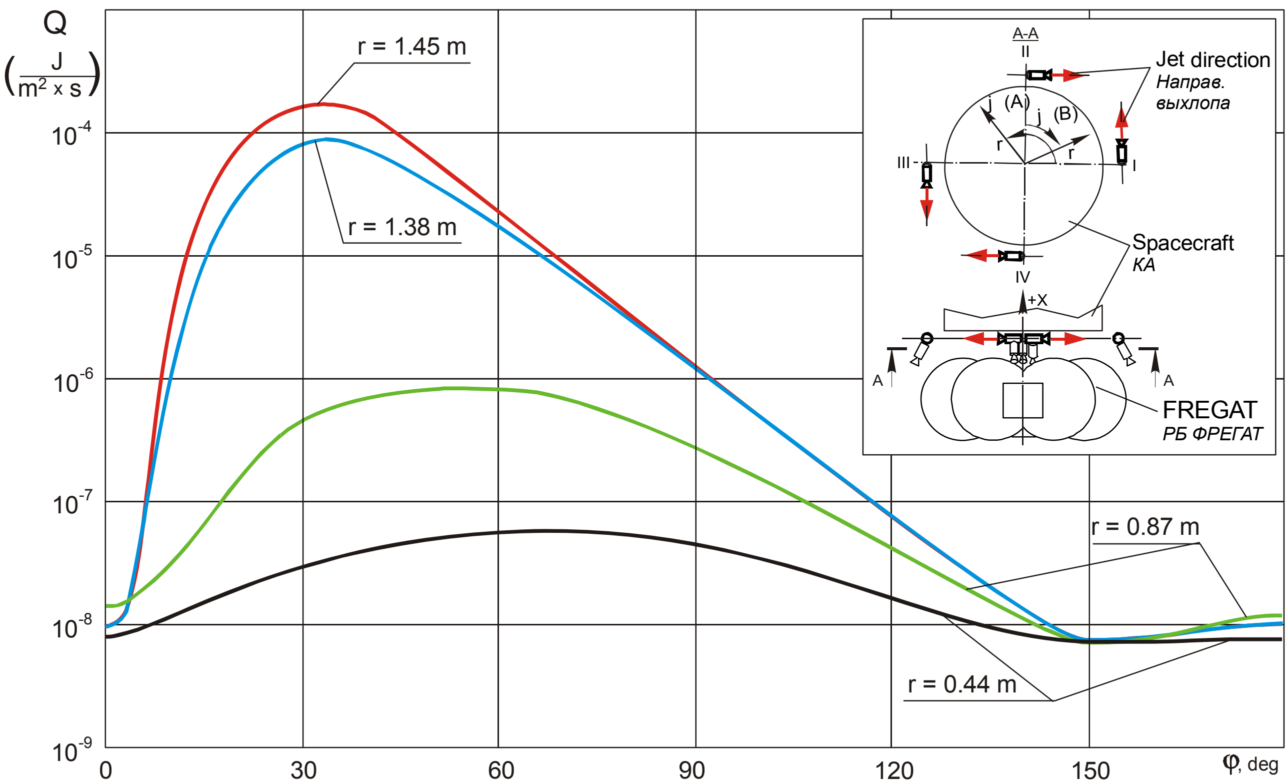



Figure 3.7 – Heat flow distribution along the spacecraft bottom surface

## 3.4. Cleanliness and contamination

### 3.4.1. Cleanliness

The following standard practices ensure that spacecraft cleanliness conditions are met:

- A clean environment is provided during production, test, and delivery of all upper-composite components (upper stage, interstage section, fairing, and adapter) to prevent contamination and accumulation of dust. The LV materials are selected not to generate significant organic deposit during all ground phases of the launch preparation.
- All spacecraft operations are carried out in EPCU buildings (PPF, HPF and UCIF) in controlled Class 100,000 clean rooms. During transfer between buildings the spacecraft is transported in payload containers (CCU) with the cleanliness Class 100 000. All handling equipment is clean room compatible, and it is cleaned and inspected before its entry in the facilities.
- Prior to the encapsulation of the spacecraft, the cleanliness of the upper stages and fairing are verified based on the Visibly Clean Level 2 criteria, and cleaned if necessary.
- Once encapsulated and during transfer and standby on the launch pad, the upper composite will be hermetically closed and a Class 10,000 TBC air-conditioning of the fairing will be provided.
- On the launch pad access can be provided to the payload. The gantry not being air-conditioned cleanliness level is ensured by the fairing overpressure.

-

| **S/C location** | **Transfer between buildings** | **S/C in EPCU and UCIF** | | **S/C on L/V** | |
|---|---|---|---|---|---|
| | In CCU container | Not encapsulated | Encapsulated * | Transfer to launch Zone* (duration 3 h) | On launch pad* |
| **Cleanliness class** | 100,000 | 100,000 | 10,000 TBC | 100,000 | 10,000 |

* Filtration of air-conditioning system: standard HEPA H14 (DOP 0.3 µm)

### 3.4.2. Contamination

During all spacecraft ground activities from spacecraft delivery to launch site up to lift-off, the maximum organic non-volatile deposit on the spacecraft surface will not exceed 2 $mg/m^2$/week. The organic contamination in facilities and under the fairing is controlled.

The LV materials are selected to limit spacecraft contamination during flight. The non-volatile organic deposit on the spacecraft surface generated by the materials outgassing does not exceed 2 $mg/m^2$.

The LV systems are designed to preclude in-flight contamination of the spacecraft. The LVs pyrotechnic devices used by the LV for fairing jettison and spacecraft separation are leak proof and do not lead to any satellite contamination.

The non-volatile organic deposit generated by the Fregat's attitude control thrusters plume on the adjacent spacecraft surfaces does not exceed 2 $mg/m^2$ for a TBD minutes mission duration with typical altitude and spin manoeuvres.

The non-volatile organic contamination generated during ground operations and flight is cumulative.

## 3.5. Electromagnetic environment

The LV and launch range RF systems and electronic equipments are generating electromagnetic fields that may interfere with satellite equipment and RF systems. The electromagnetic environment depends from the characteristics of the emitters and the configuration of their antennas.

### 3.5.1. LV and range RF systems

**Launcher**

The basic RF characteristics of the LV transmission and reception equipment are given in Table 3.7.

**Range**

The ground radars, local communication network and other RF mean generate an electromagnetic environment at the preparation facilities and launch pad, and together with LV emission constitute an integrated electromagnetic environment applied to the spacecraft. The EM data are based on the periodical EM site survey conducted at CSG.

### 3.5.2. The electromagnetic field

The intensity of the electrical field generated by spurious or intentional emissions from the launch vehicle and the range RF systems do not exceed those given in Figure 3.8. These levels are measured at adapter/Fregat interface.

Actual levels will be the same or lower taking into account the attenuation effects due to the adapter/dispenser configuration, or due to worst case assumptions taken into account in the computation.

Actual spacecraft compatibility with these emissions will be assessed during the preliminary and final EMC analysis.

Table 3.7 - LV RF system characteristics

| | Equipment | Frequency (MHz) | Power (W) | Power (dBW) | Antenna (Number) |
|---|---|---|---|---|---|
| **SOYUZ 3 STAGES** | | | | | |
| Transmitters | TM System | 2200 - 2290 | TBD | — | 2 |
| | | 2200 – 2290* | TBD | — | 1 |
| | Radar transponder system | 5400 - 5900 | 400 (pick 0,8 μs) | | 2 |
| Receivers | Radar transponder system | 5690 | — | - 164 | 2 |
| | Satellite Navigation System "SSN" | 1595 ± 25 | — | - 165 | 2 |
| | TC Neutralisation | 440-460 | — | | 2 |
| **FREGAT** | | | | | |
| Transmitters | Tracking RDM*** | 2805 ± 11 | 0.075/ 100***** | — | 2 |
| | Tracking PPU**** | 3410 ± 0.125 | 3 | — | 1 |
| | Telemetry TMC-M4** | 2200 - 2290 | TBD | — | 1 |
| | | | TBD | — | 2 |
| Receivers | Satellite Navigation System "SSN" | 1595 ± 25 | — | - 165 | 2 |
| | Tracking RDM | 2725 ± 14 | — | - 126 | 2 |
| | Tracking PPU | 5754.9 ± 0.3 | — | - 146 | 1 |

Note:

* Redundant channel with a 3-second transmission delay with the nominal one.

** The TMC-M4 system comprises one transmitter and three antennas:

- One antenna, equipped with a reflector and located on the interstage section below the Fregat, operates as long as the Fregat is not separated from the third stage; and
- Two antennas, located on the top of the Fregat, operate after Fregat separation.

*** The RDM system is switched "on" 20 minutes before the launch and is functional for a range up to 8000 km. It comprises one transmitter, one receiver, and two antennas. Each antenna ensures both transmission and reception.

**** The PPU system is designed for a range between 1000 and 45,000 km, and is switched "on" during flight when the Fregat reaches an altitude higher than 1000 km. It comprises one transmitter and one receiver, each associated with one antenna.

***** Average power 0.075 W; for a 0.7-μs impulse: 100 W

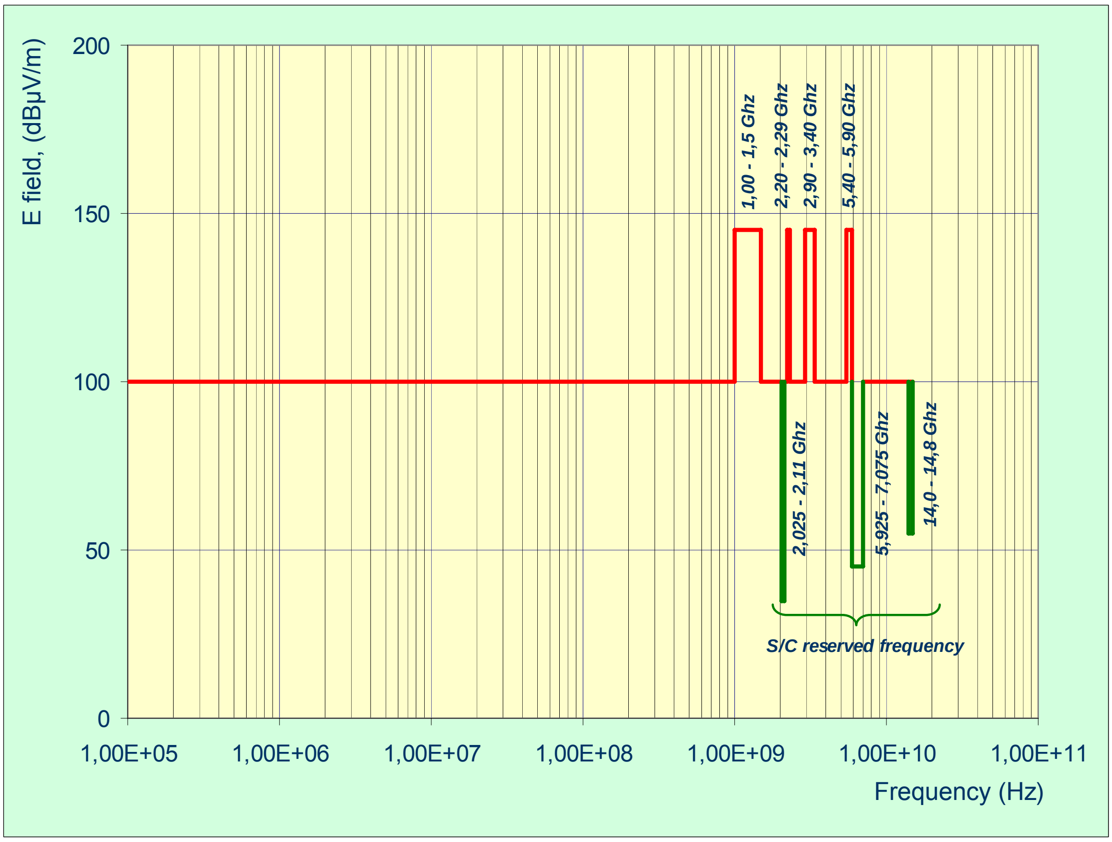



Figure 3.8 – Spurious Radiation by Launch Vehicle and Launch Base
Narrow-band Electrical field (TBD)

## 3.6. Environment verification

The Soyuz and Fregat telemetry system capture the low and high frequency data during the flight from the sensors installed on the fairing, upper stage and adapter and then relay this data to ground station. These measurements are recorded and processed during post-launch analysis, a synthesis of the results is provided to the customer.

Should a Customer provides the adapter, Arianespace will supply the Customer with transducers to be installed on the adapter close to the interface plane if needed.

# SPACECRAFT DESIGN AND VERIFICATION REQUIREMENTS — Chapter 4

## 4.1. Introduction

The design and dimensioning data that shall be taken into account by any Customer intending to launch a spacecraft compatible with the Soyuz launch vehicle are detailed in this chapter.

## 4.2. Design requirements

### 4.2.1. Safety Requirements

The User is required to design the spacecraft in conformity with the CSG Safety Regulations.

### 4.2.2. Selection of spacecraft materials

In case of a dual launch or of a launch with a co-passenger, the spacecraft materials must satisfy the following outgassing criteria:

- Total Mass Loss (TML) ≤ 1 %;
- Collected Volatile Condensable Material (CVCM) ≤ 0.1 %.

measured in accordance with the procedure "ECSS-Q-70-02A".

### 4.2.3. Spacecraft Properties

#### 4.2.3.1. Payload mass and CoG limits

Off-the-shelf adapters provide accommodation for a wide range of spacecraft masses and centre of gravity. See annexes referring to adapters for detailed values.

For satellites with characteristics outside these domains, please contact Arianespace.

#### 4.2.3.2. Static unbalance

The centre of gravity of the spacecraft must stay within a distance d ≤ 15 mm from the launcher longitudinal axis.
Higher offsets can be accommodated but must be compensated on the LV side, and must therefore be specifically analysed.

#### 4.2.3.3. Dynamic unbalance

There is no predefined requirement for spacecraft dynamic balancing with respect to ensuring proper operation of the LV. However, these data have a direct effect on spacecraft separation.

To ensure the separation conditions in spin-up mode described in the Chapter 2, the maximum spacecraft dynamic unbalance ε corresponding to the angle between the spacecraft longitudinal geometrical axis and the principal roll inertia axis shall be:
$\varepsilon \leq 1$ degree.

#### 4.2.3.4. Frequency Requirements

To prevent dynamic coupling with fundamental modes of the LV, the spacecraft should be designed with a structural stiffness which ensures that the following requirements are fulfilled. In that case the design limit load factors given in next paragraph are applicable.

**Lateral frequencies**

The fundamental frequency in the lateral axis of a spacecraft hard-mounted at the interface must be as follows with an off-the shelf adapter:

$\geq$ 15 Hz for spacecraft mass $\leq$ 5000 kg

No local mode should be lower than the first fundamental frequencies.

**Longitudinal frequencies:**

The fundamental frequency in the longitudinal axis of a spacecraft hard-mounted at the interface must be as follows with an off-the shelf adapter:

$\geq$ 35 Hz for spacecraft mass $\leq$ 5000 kg

No local mode should be lower than the first fundamental frequencies.

### 4.2.4. Dimensioning Loads

#### 4.2.4.1. The design load factors

The design and dimensioning of the spacecraft primary structure and/or evaluation of compatibility of existing spacecraft with Soyuz launch vehicle shall be based on the design load factors.

The design load factors are represented by the Quasi-Static Loads (QSL) that are the more severe combinations of dynamic and steady-state accelerations that can be encountered at any instant of the mission (ground and flight operations).

The QSL reflects the line load at the interface between the spacecraft and the adapter (or dispenser).

The flight limit levels of QSL for a spacecraft launched on Soyuz, and complying with the previously described frequency requirements and with the static moment limitation are given in the Table 4.1.

Table 4.1 - Design limit load factors

| Load Event | | QSL (g) (+ = tension; – = compression) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Lateral | | | Longitudinal | | |
| | | Static | Dynamic | Total | Static | Dynamic | Total |
| 1 | Liftoff | ±0.2 | ±1.6 | ±1.8 | –1.0 | ±0.6 | min –1.6<br>max –0.4 |
| 2 | Flight with maximum dynamic pressure (Qmax) | ±0.4 | ±0.6 | ±1.0 | –2.2 | ±0.4 | min –2.6<br>max –1.8 |
| 3 | First-stage flight with maximal acceleration | ±0.1 | ±0.4 | ±0.5 | –4.3 | ±0.7 | min –5.0<br>max –3.6 |
| 4 | Separation between first and second stages | ±0.2 | ±0.8 | ±1.0 | –4.1<br>–1.0 | 0.0<br>±0.3 | min –4.1<br>max –0.7 |
| 5 | Second-stage flight | ±0.1 | ±0.7 | ±0.8 | –2.6<br>–1.0 | ±1.2<br>±0.3 | min –3.8<br>max –0.7 |
| 6 | Separation between second and third stages | ± 0.2 | ± 0.6 | ± 0.8 | –2.6<br>–0.2 | 0.0<br>±1.5 | min –2.6<br>max +1.3 |
| 7 | Beginning of third-stage flight | ± 0.2 | ± 0.5 | ± 0.7 | –1.2 | ±1.5 | min –2.7<br>max +0.3 |
| 8 | Third-stage engine cutoff | ± 0.1 | ± 0.2 | ± 0.3 | –3.7<br>0.0 | 0.0<br>±1.5 | min –3.7<br>max +1.5 |

Note:

- The factors apply on payload CoG
- The minus signs indicate compression along the longitudinal axis and the plus signs tension.
- Lateral loads may act in any direction simultaneously with longitudinal loads
- The gravity load is included
- For the structural design, additional safety coefficients shall be applied as defined in paragraph 4.3.2.

#### 4.2.4.2. Line loads peaking

The geometrical discontinuities and differences in the local stiffness of the LV (stiffener, holes, stringers, ...) and the non-uniform transmission of the LV's thrust at the spacecraft/adapter interface may produce local variations of the uniform line loads distribution.

**Line loads peaking induced by the Launch Vehicle:**

The integral of these variations along the circumference is zero, and the line loads derived from the QSL are not affected, but for the correct dimensioning of the lower part of the spacecraft this excess shall be taken into account and has to be added uniformly at the S/C/adapter interface to the mechanical fluxes obtained for the various flight events.

Such local over line loads are specific of the adapter design. For off-the-shell adapters a value of 15% over the line loads seen by the spacecraft is assumed.

**Picking loads induced by spacecraft:**

The maximum value of the peaking line load induced by the spacecraft is allowed in local areas to be up to 10% over the dimensioning flux seen by adapter under limit load conditions. An adaptor mathematical model can be provided to assess these values.

#### 4.2.4.3. Handling loads during ground operations

During the encapsulation phase, the spacecraft is lifted and handled with its adapter: for this reason, the spacecraft and its handling equipment must be capable of supporting an additional mass of 110kg.

The crane characteristics, velocity and acceleration are defined in the EPCU User's Manual.

#### 4.2.4.4. Dynamic loads

The secondary structures and flexible elements (e.g., solar panels, antennas, and propellant tanks) must be designed to withstand the dynamic environment described in Chapter 3 and must take into account the safety factors defined in paragraph 4.3.2.

### 4.2.5. Spacecraft RF emission

To prevent the impact of spacecraft RF emission on the proper functioning of the LV electronic components and RF systems during ground operations and in flight, the spacecraft should be designed to respect the LV susceptibility levels given in Figure 4-1. In particular, the spacecraft must not overlap the frequency bands of the LV, 2206.5 MHz, 2227 MHz, 2254.5 MHz, 2267.5 MHz And 2284 MHz with a margin of 1 MHz.

The spacecraft transmission is allowed during ground operations. Authorisation of transmission during countdown, and/or flight phase and spacecraft separation will be considered on a case by case basis. In any case, no change of the spacecraft RF configuration (no frequency change, no power change) is allowed between $H_0$ – 1h30m until 20 s after separation.

During the launch vehicle flight until separation of the spacecraft (s) no uplink command signal can be sent to the spacecraft or generated by a spacecraft on-board system (sequencer, computer, etc...).

For dual launch, in certain cases, a transmission time sharing plan may be set-up on Arianespace request.

Spacecraft transmitters have to meet general IRIG specifications.

TO BE ISSUED LATER

A specification of 100 dBμV/m from 10 MHz to 20 GHz has to be considered before further refinement.

Figure 4-1 – Spurious radiations acceptable to launch vehicle
Narrow-band electrical field measured at the FREGAT/adapter interface

## 4.3. Spacecraft compatibility verification requirements

### 4.3.1. Verification Logic

The spacecraft authority shall demonstrate that the spacecraft structure and equipments are capable of withstanding the maximum expected launch vehicle ground and flight environments.

The spacecraft compatibility must be proven by means of adequate tests. The verification logic with respect to the satellite development program approach is shown in Table 4.2.

Table 4.2 – Spacecraft verification logic

| S/C development approach | Model | Static | Sine vibration | Random vibration | Acoustic | Shock |
|---|---|---|---|---|---|---|
| With Structural Test Model (STM) | STM | Qual. test | Qual. test | Qual. test | Qual. test | Shock test characterization and analysis |
| | FM1 | By heritage from STM * | Protoflight test** | Protoflight test** | Protoflight test** | Shock test characterization and analysis or by heritage* |
| | Subsequent FM's | By heritage from STM * | Acceptance test (optional) | Acceptance test (optional) | Acceptance test | By heritage* |
| With ProtoFlight Model | PFM = FM1 | Qual test or by heritage * | Protoflight test** | Protoflight test** | Protofligt test** | Shock test characterization and analysis or by heritage* |
| | Subsequent FM's | By heritage * | Acceptance test (optional) | Acceptance test (optional) | Acceptance test | By heritage* |

* If qualification is claimed "by heritage" , the representativeness of the structural test model (STM) with respect to the actual flight unit must be demonstrated.

* *Protoflight approach means qualification levels and acceptance duration/sweep rate.

The mechanical environmental test plan for spacecraft qualification and acceptance shall comply with the requirements presented hereafter and shall be reviewed by Arianespace prior to implementation of the first test.

Also, it is suggested, that Customers will implement tests to verify the susceptibility of the spacecraft to the thermal and electromagnetic environment and will tune, by these way, the corresponding spacecraft models used for the mission analysis.

### 4.3.2. Safety factors

Spacecraft qualification and acceptance test levels are determined by increasing the design load factors (the flight limit levels) — which are presented in Chapter 3 and Chapter 4 — by the safety factors given in Table 4.3. The spacecraft must have positive margins of safety for yield and ultimate loads.

Table 4.3 - Test Factors, rate and duration

| SC tests | Qualification | | Protoflight | | Acceptance | |
|---|---|---|---|---|---|---|
| | Factors | Duration/ Rate | Factors | Duration | Factors | Duration |
| Static (QSL) | 1.3 ultimate<br>1.1 yield | N/A | 1.3 ultimate<br>1.1 yield | N/A | N/A | N/A |
| Sine vibrations | 1.3 | 0.5 oct/min | 1.3 | 1.0 oct/min | 1.0 | 1.0 oct/min |
| Random vibrations | 2.25(*) | TBD | 2.25(*) | TBD | 1.0 (*) | TBD |
| Acoustics | 1.41<br>(or +3 dB) | 120 s | 1.41<br>(or +3 dB) | 60 s | 1.0 | 60 s |
| Shock | 1.41<br>(or +3 dB) | N/A | 1.41<br>(or +3 dB) | N/A | N/A | N/A |

Note:

(*) - Factor by which to multiply the Power Spectral Density.

### 4.3.3. Spacecraft compatibility tests

#### 4.3.3.1. Static tests

Static load tests (in the case of an STM approach) are performed by the customer to confirm the design integrity of the primary structural elements of the spacecraft platform. Test loads are based on worst-case conditions — i.e., on events that induce the maximum mechanical fluxes into the main structure, derived from the table of maximum QSLs and taken into account the additional line loads peaking.

The qualification factors given previously shall be considered.

#### 4.3.3.2. Sinusoidal vibration tests

The objective of the sine vibration tests is to verify the spacecraft secondary structure dimensioning under the flight limit loads multiplied by the appropriate safety factors.

The spacecraft qualification test consists of one sweep through the specified frequency range and along each axis.

Flight limit amplitudes are specified in Chapter 3 and are applied successively on each axis. The tolerance on sine amplitude applied during the test is ± 10%.

A notching procedure may be agreed on the basis of the latest coupled loads analysis (CLA) available at the time of the tests to prevent excessive loading of the spacecraft structure. However, it must not jeopardize the tests objective to demonstrate positive margins of safety with respect to the flight loads.

Sweep rates may be increased on a case-by-case basis depending on the actual damping of the spacecraft structure. This is done while maintaining the objective of the sine vibration tests.

Table 4.4 – Sinusoidal vibration tests levels

| **Sine** | **Frequency range (Hz)** | **Qualification levels (0-peak) g** | **Acceptance levels (0-peak) g** |
|---|---|---|---|
| **Longitudinal** | 5 – 10<br>10 – 30<br>30 – 40 | 0.65<br>1.3 g<br>0,78 g | 0.5 g<br>1 g<br>0.6 g |
| **Lateral** | 1 – 5<br>5 – 30<br>30 – 40 | 0.39 g<br>1.04 g<br>0.78 g | 0.3 g<br>0.8 g<br>0.6 g |
| **Sweep rate** | | 0.5 oct./min | 1 oct./min |

#### 4.3.3.3. Random vibration tests

The verification of the spacecraft structure compliance with the random vibration environment in the 40 Hz - 100 Hz frequency range shall be performed.

Three methodologies can be followed:

Method Number One: Perform a dedicated random vibration qualification test.

| Frequency band | Spectral density ($10^{-3}$ $g^2$/Hz) | |
|---|---|---|
| | Qualification | Acceptance |
| 20 – 50 | 11.25 | 5 |
| 50 – 100 | 11.25 – 22.5 | 5 – 10 |
| 100 – 200 | 22.5 – 56.25 | 10 – 25 |
| 200 – 500 | 56.25 | 25 |
| 500 – 1000 | 56.25 – 22.5 | 25 – 10 |
| 1000 – 2000 | 22.5 – 11.25 | 10 – 5 |
| Overall (g) | 7.5 | 5 |

Method Number Two: Conduct the sine vibration qualification test up to 100 Hz and apply input levels high enough to cover the random vibration environment (equivalency obtained with the Miles formula).

$$G_{RMS} = \sqrt{\frac{\pi}{2} \cdot f_n \cdot Q \cdot PSD_{input}}$$

where

$G_{RMS}$ - root mean square acceleration, g

$f_n$ - Natural frequency, Hz

$Q$ – Amplification factor at frequency $f_n$, $Q = \frac{1}{2 \cdot \zeta}$

where $\zeta$ is the critical damping ratio

$PSD_{input}$ - Input Power Spectral Density at $f_n$, $g^2$/Hz

Method Number Three: Conduct the sine vibration qualification test up to 100 Hz so as to restitute the structural transfer functions and then demonstrate the compliance of the spacecraft secondary structure with the random vibration environment by analysis.

Above 100 Hz, spacecraft qualification with respect to the random vibration environment is obtained through the acoustic vibration test.

#### 4.3.3.4. Acoustic vibration tests

Acoustic testing is accomplished in a reverberant chamber applying the flight limit spectrum provided in Chapter 3 and increased by the appropriate safety factors. The volume of the chamber with respect to that of the spacecraft shall be sufficient so that the applied acoustic field is diffuse. The test measurements shall be performed at a minimum distance of 1 m from spacecraft.

Table 4.5 – Acoustic vibration test levels

| Octave Center Frequency (Hz) | Flight Limit Level (dB) (reference: 0 dB= 2 x $10^{-5}$ Pa) | | Test tolerance |
|---|---|---|---|
| | ST-Type Fairing | | |
| | Acceptance | Qualification | |
| 31.5 | 125 | 128 | -2, +4 |
| 63 | 132 | 135 | -1, +3 |
| 125 | 134 | 137 | -1, +3 |
| 250 | 136 | 139 | -1, +3 |
| 500 | 134 | 137 | -1, +3 |
| 1000 | 125 | 128 | -1, +3 |
| 2000 | 121 | 124 | -1, +3 |
| OASPL | 141 | 144 | -1, +3 |
| Test duration | 60s | 120s | |

No fill factor correction is applied.

#### 4.3.3.5. Shock qualification

The demonstration of the spacecraft's ability to withstand the separation shock generated by the LV shall be based on one of the two following methods:

Method Number One: Qualification by release test and analytic demonstration.

• A clamp-band release test is conducted with the tension of the belt set as close as possible to its maximum value, during which interface levels and equipment base levels are measured. This test can be performed on the STM, on the PFM, or on the first flight model provided that the spacecraft structure close to the interface as well as the equipment locations and associated supports are equivalent to those of the flight model. The release test is performed twice.

• An analytic demonstration of the qualification of each piece of equipment is conducted. This analytic demonstration is performed as follows:

- The release shocks generated at the spacecraft's interface and measured during the two above-mentioned tests are compared to the release-shock specified envelope. The difference derived from the above comparison is then considered to extrapolate the measured equipment base levels to the maximum levels that can actually be observed during clamp-band release.

- These extrapolated shock levels are then increased by a safety factor of +3 dB and are compared to each piece of equipment qualification status. Note that each unit qualification status can be obtained from environmental qualification tests other than shock tests by using equivalent rules (e.g., from sine or random vibration tests).

Method Number Two – Qualification by heritage

An analysis is conducted on the basis of multiple previous clamp-band release tests (i.e., on a comprehensive shock database).

The acceptance test consists of performing a clamp-band release under nominal conditions (nominal tension of the band, etc.). This single release test is usually performed at the end of the mechanical fit-check. A flight type adapter with the associated separation systems and consumable items can be provided in support of these shock tests as an optional service.

# SPACECRAFT INTERFACES Chapter 5

## 5.1. Introduction

The Soyuz launch vehicle provides standard interfaces that fit most of spacecraft buses and satellites and allows an easy switch between the launch vehicles of the European Transportation Fleet.

This chapter covers the definition of the spacecraft interfaces with the payload adapter, the fairing, the dual launch structure and the on-board and ground electrical equipment.

The spacecraft is mated to the LV through a dedicated structure called an adapter that provides mechanical interface, electrical harnesses routing and systems to assure the spacecraft separation. Off-the-shelf adapters, with separation interface diameter of 937 mm, 1194 mm, and 1666 mm are available.

For dual launches, an internal carrying structure can be proposed, that houses the lower passenger and carries the upper passenger.

The payload fairing protects the spacecraft from external environment during the flight as on the ground, providing at the same time specific access to the spacecraft during ground operations.

The electrical interface provides communication with the launch vehicle and the ground support equipment during all phases of spacecraft preparation, launch and flight.

The adapters/dispensers and fairings accommodate also the telemetry sensors that are used to monitor the spacecraft flight environment.

These elements could be subject of mission specific adaptation, as necessary, to fit with the Customer requirements. Their respective compatibility with the spacecraft is managed through the Interface Control Document (ICD).

## 5.2. The reference axes

All definition and requirements shall be expressed in the same reference axis system to facilitate the interface configuration control and verification.

Figure 5-1 shows the three-stage vehicle and the Fregat upper-stage coordinate system that are the reference axis system.

The clocking of the spacecraft with regard to the launch vehicle axes is defined in the Interface Control Document taking into account the spacecraft characteristics (volume, access needs, RF links, …).

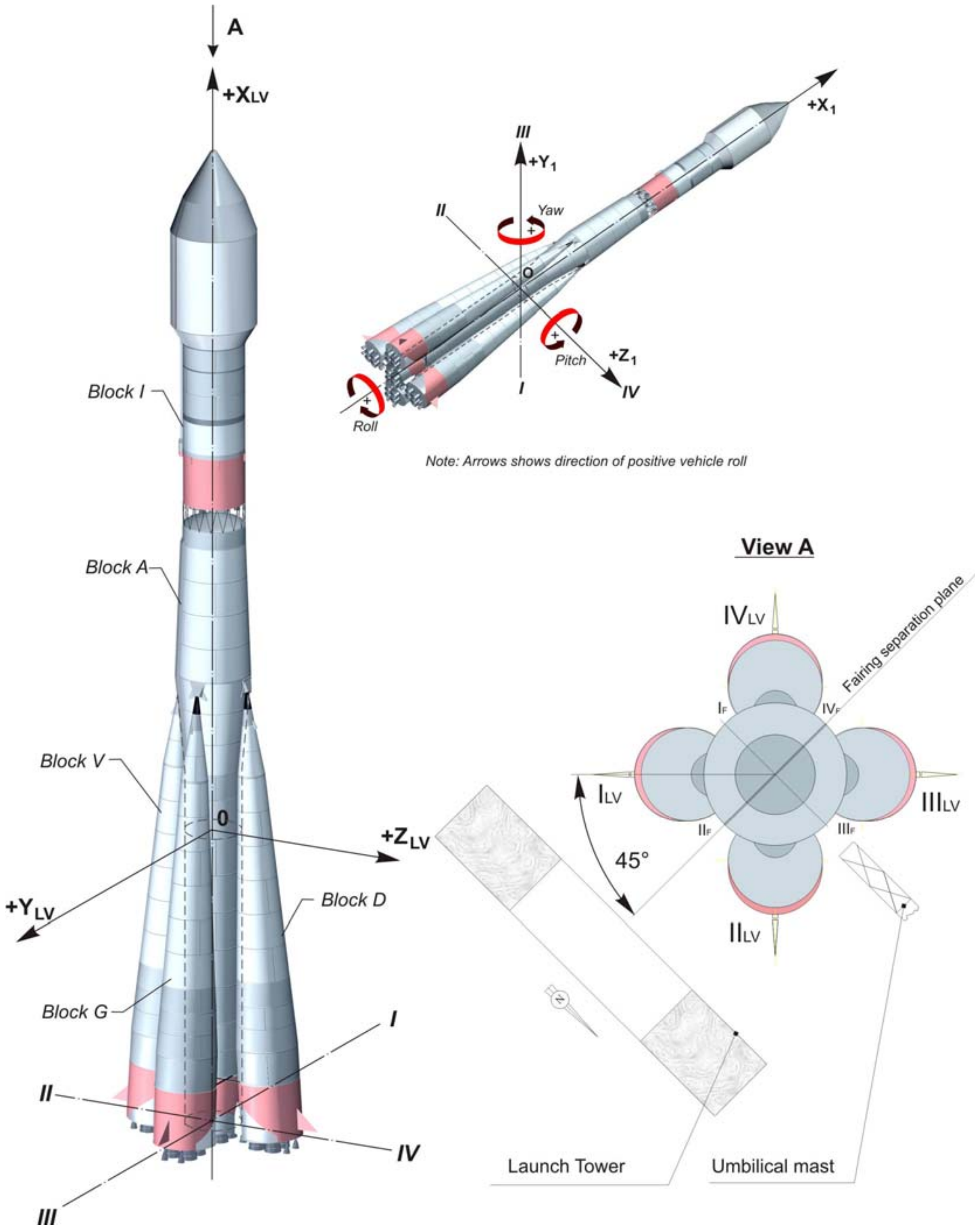



Figure 5-1 – Soyuz coordinate system

## 5.3. Encapsulated spacecraft interfaces

### 5.3.1. Payload usable volume definition

The payload usable volume is the area under the fairing, or the dual launch carrying structure, available to the spacecraft mated on the adapter/dispenser. This volume constitutes the limits that the static dimensions of the spacecraft, including manufacturing tolerance, thermal protection installation, appendices …, may not exceed.

It has been established having regard to the potential displacement of the spacecraft complying with frequency requirements described in the Chapter 4.

Allowance has been made for manufacturing and assembly tolerances of the upper part (fairing, intermediate bay, upper stage and adapter), for all displacements of these structures under ground and flight loads, and for necessary clearance margin during carrying structure separation.

In the event of local protrusions located slightly outside the above-mentioned envelope, Arianespace and the Customer can conduct a joint investigation in order to find the most suitable layout.

The payload usable volume is shown in Figure 5-2. The allocated volume envelope in the vicinity of the adapter/dispensed is described in the annexes dedicated to the each of the off-the-shelf adapters.

Accessibility to the mating interface, separation system functional requirements and non-collision during separation are also considered for its definition.

### 5.3.2. Spacecraft accessibility

The encapsulated spacecraft can be accessible for direct operations up to 4 hour 30 minutes (TBC) before lift-off through the access doors of the fairing structure. If access to specific areas of spacecraft is required, additional doors can be provided on a mission-specific basis. Doors shall be installed in the authorized areas.

The payload platform of the gantry is not air-conditioned, cleanliness in the fairing is ensured through the overpressure generated by the fairing ventilation. Specific means can be provided (TBC) to ensure access from a protected area.

The same procedures is applicable to the optional radio-transparent windows. The radio-transparent window may be replaced by RF repeater antenna.

The access and RF transparent window areas are presented in Figure 5-3.

### 5.3.3. Special on-fairing insignia

A special mission insignia based on Customer supplied artwork can be placed by Arianespace on the cylindrical section of the fairing. The dimensions, colors, and location of each such insignia are the subject to mutual agreement. The artwork shall be supplied not later then 6 months before launch.

### 5.3.4. Payload compartment description

#### Nose fairing description

The ST fairing consists of a two-half-shell carbon-fiber reinforced plastic (CFRP) sandwich structure with aluminum honeycomb core. The total thickness is approximately 25 mm.

A 20-mm-thick thermal cover made of polyurethane foam with a protective liner is applied to the internal surface of the cylindrical part of the fairing.

The separation system consists of longitudinal and lateral mechanical locks linked together by pushing rods and connected to pyro pushers. 4 vertical jacks powered by a pyrotechnic gas generator are used for opening and rotation of the two fairing halves. The final jettisoning is provided by lateral springs.

This separation system, standard for Russian launch vehicles, produces low shocks at separation and allows its functionality to be verified during launch vehicle acceptance tests.

The payload volume is shown in Figure 5-2.

#### Carrying structure description

A dual launch internal carrying structure has been studied in order to make the best use of the Soyuz performance in Low Earth orbits such as SSO.
The usable volume offered for the upper and lower passengers are defined in Figure 5-4.
Any of the Soyuz adapters can be used in conjunction with this carrying structure to provide for separation.

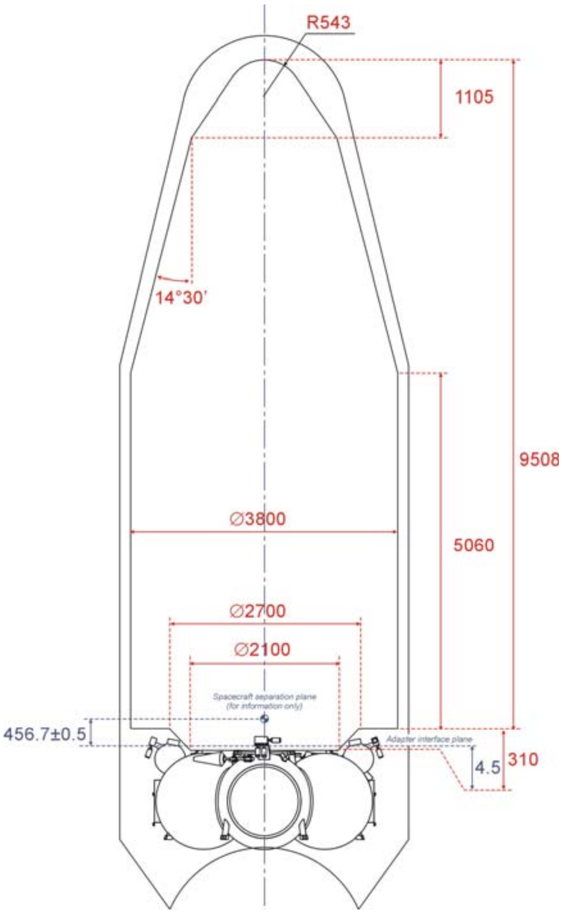



Figure 5-2 – ST fairing payload volume

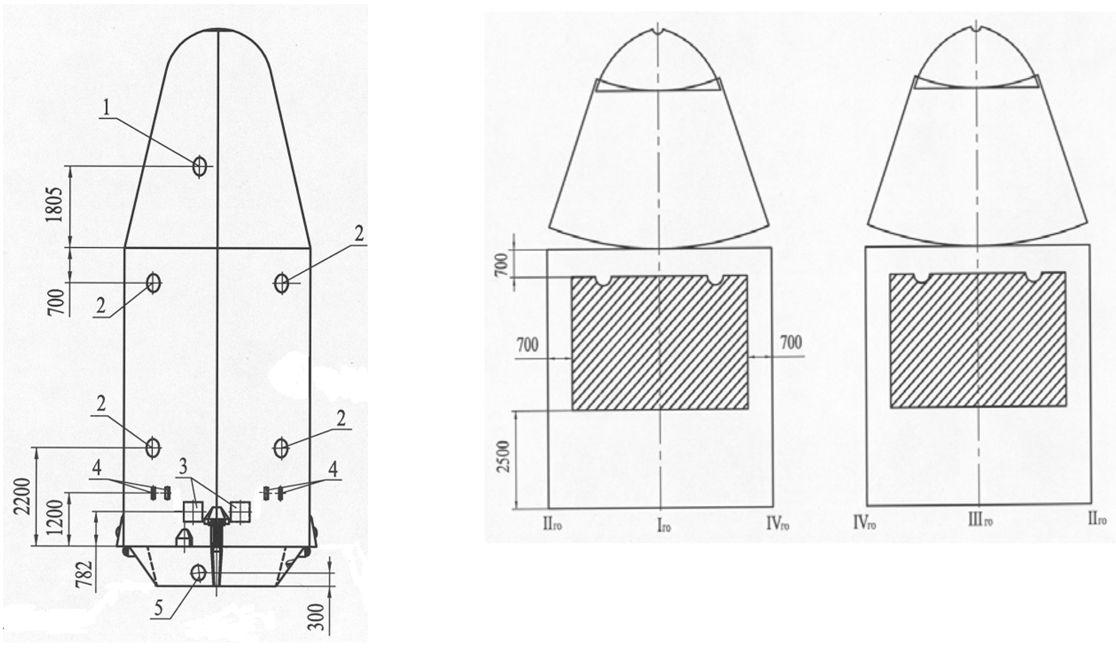



Figure 5-3 – ST fairing access door and RF transparent window areas.

1 & 5 – Air-conditioning system hatches
2 – 8 satellite access doors with a diameter 400 mm
3 – 4 Fregat access doors
4 – Venting ports to ensure the correct venting of the upper composite

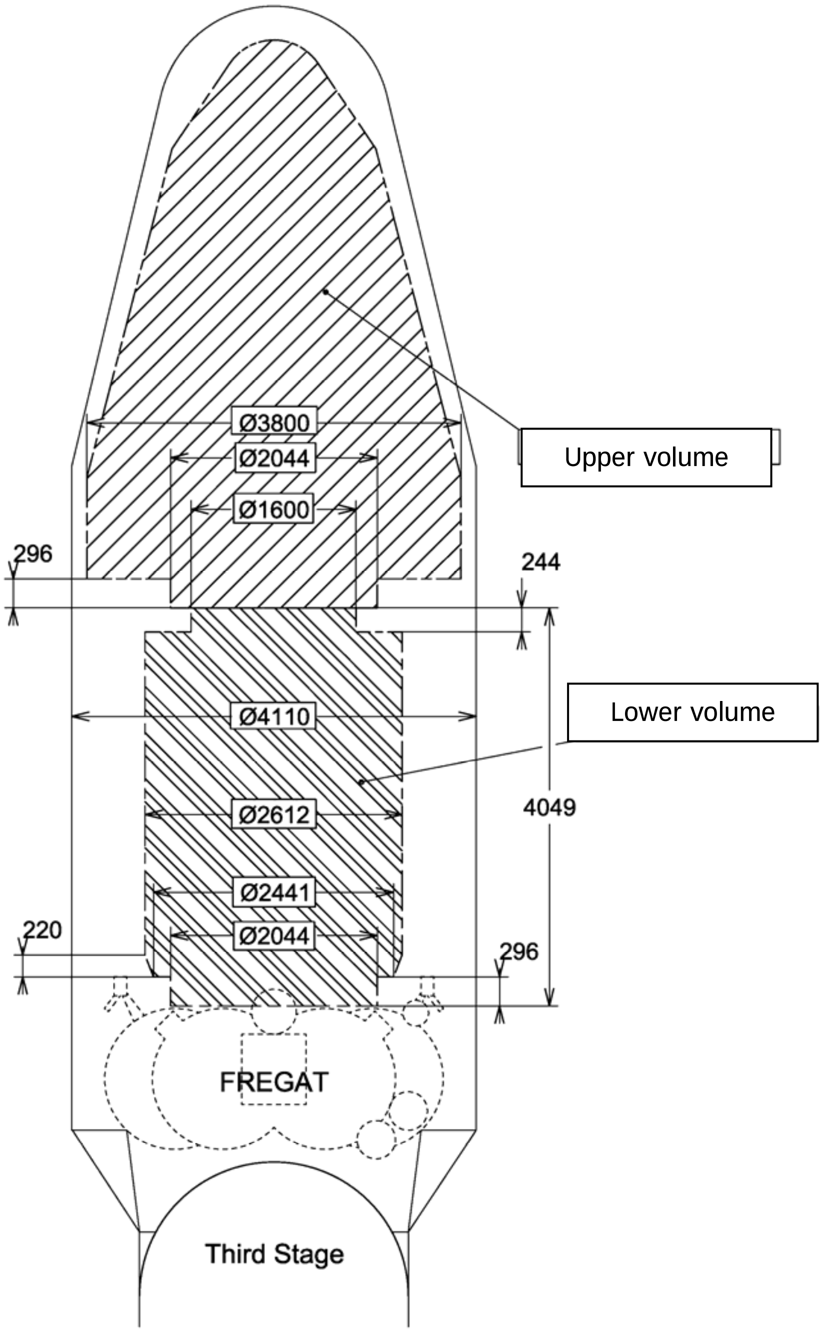



Figure 5-4 – Soyuz internal dual launch carrying structure usable volumes

## 5.4. Mechanical Interface

The Soyuz offers a range of standard off-the-shelf adapters and their associated equipment, compatible with most of the spacecraft platforms. **These adapters belong to the family of the Ariane and Vega adapters providing the same interface definition on the spacecraft side.** Their only specificity is the accommodation to the Fregat upper stage standard interface plane with a diameter of 2000mm , at the adapter bottom side.

The Customer will use full advantage of the off-the-shelf adapters. Nevertheless dedicated adapter or dispenser (especially in the case of dispensers) can be designed to address specific Customer's needs and requirements.

All adapters are equipped with a payload separation system, brackets for electrical connectors.

In some cases to reduce the production time or facilitate the switch between LV, Ariane adapters can be used directly with the Soyuz LV. For this case a dedicated structure will be used to adapt the lower interface to the Fregat mating interface.

The payload separation system is a clamp-band system consisting of a clamp band set, release mechanism and separation springs.

The electrical connectors are mated on two brackets installed on the adapter and spacecraft side. On the spacecraft side, the umbilical connector's brackets must be stiff enough to prevent any deformation greater than 0.5 mm under the maximum force of the connector spring.

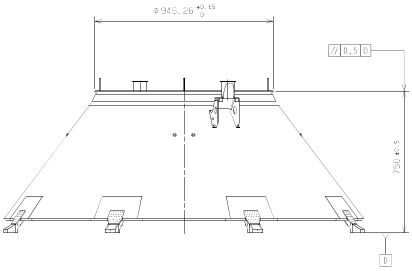
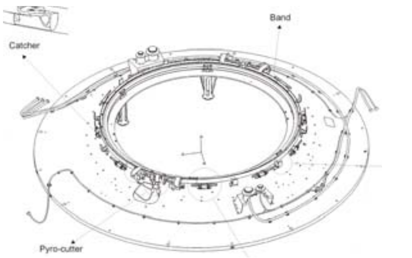
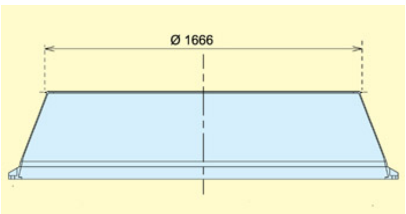
**Standard Soyuz adapters:**

The general characteristics of the off-the-shelf adapters and adaptation structures are presented in the Table 5.1. A more detailed description is provided in the Annex 4. A dispenser design, flight proven on previous missions, is given in Annex 4 as an example.

Note:

In some situations, the Customer may wish to assume responsibility for payload adapter/dispenser. In such cases, the Customer shall ask the Arianespace approval and corresponding requirements. Arianespace will supervise the design and production of such equipment to insure the compatibility at system level.

Table 5.1 – SOYUZ standard adapters

| Adapter | Description | Separation system | Reference |
|---|---|---|---|
| **937-SF**  | H=750 mm<br>M < 40 kg<br>Truncated cone composite structure (sandwich with CFRP skins and an aluminium-honeycomb core). The upper ring and the eight lower brackets are made of aluminium alloys | 937B (CASA)<br>Tension < 27,7 kN | Flight qualified (Mars Express, 2003) |
| **1194-SF**   | H=230 mm<br>M < 110 kg<br>Truncated cone composite structure (sandwich with CFRP skins and an aluminium-honeycomb core). The upper and lover rings are made of aluminium alloys. | 1194A (SAAB)<br>Tension < 30,1 kN | Flight qualified (Cluster mission, 2000) |
| **1666-SF**   | H=457 mm<br>M < 90 kg<br>Truncated cone composite structure (sandwich with CFRP skins and an aluminium-honeycomb core).The upper and lover rings are made of aluminium alloys. | 1666H (EADS-CASA) | First flight 2006 |

## 5.5. Electrical and radio electrical interfaces

The needs of communication with the spacecraft during the launch preparation and the flight require electrical and RF links between the spacecraft, LV, and the EGSE located at the launch pad and preparation facilities.

The electrical interface composition between spacecraft and the Soyuz LV is presented in the Table 5.2. The wiring diagram for the launch pad configuration is shown on Figure 5-.

All other data and communication network used for spacecraft preparation in the CSG facilities are described in Chapter 6.

Table 5.2 - Spacecraft to launch vehicle electrical and RF interfaces

| Service | Description | Lines definition | Provided as | I/F connectors* |
|---|---|---|---|---|
| Umbilical lines | Spacecraft TC/TM data transmission and battery charge | 92 lines (see §5.5.1)*** | Standard | 2 × 37** pin or<br>2 × 61 pin<br>DBAS 70 37 OSN (TBD)<br>DBAS 70 37 OSY (TBD) |
| | | 14 lines (see §5.5.1) | Standard | |
| | | Additional lines<br>(see §5.5.1.4) | Optional | |
| LV electrical functions for spacecraft | Separation monitoring | (see §5.5.2.1) | Standard | |
| | Dry loop commands | (see §5.5.2.2) | Optional | |
| | Electrical commands | (see §5.5.2.3) | Optional | |
| | Spacecraft TM retransmission | (see §5.5.2.4) | Optional | |
| | Additional power supply during flight | (see §5.5.2.5) | Optional | |
| | Pyrotechnic command | (see §5.5.2.6) | Optional | 2 × 12 pin<br>DBAS 70 12 OSN<br>DBAS 70 12 OSY |
| RF link | Spacecraft TC/TM data transmission | RF transparent windows or passive repeaters<br>(see §5.5.4) | Optional | N/A |

Note:

* Arianespace will supply the Customer with the spacecraft side interface connectors compatible with equipment of the off-the-shelf adaptors.

** The Customer will reserve three pins on each connector: one for shielding and two for spacecraft telemetry separation monitoring as described hereafter.

*** Depending on S/C power requirements lines can have to be wired in parallel.

**Flight constraints**

**During the powered phase** of the launch vehicle and up to separation of the payload(s), no command signal can be sent to the payload(s), or generated by a spacecraft onboard system (sequencer, computer, etc...). During this powered phase a waiver can be studied to make use of commands defined in this paragraph providing that the radio electrical environment is not affected.
**After the powered phase and before the spacecraft separation**, the commands defined in this paragraph can be provided to the spacecraft.
To command operations on the payload after separation from the launch vehicle, microswitches or telecommand systems (after 20 s) can be used. Initiation of operations on the payload after separation from the launch vehicle, by a payload on-board system programmed before lift-off, must be inhibited until physical separation.

H0 – 1h30 mn Upper stage burn-out Separation Separation + 20 s

| | | | | |
|---|---|---|---|---|
| Command | NO | NO | NO | YES |
| Spacecraft Sequencer | NO | NO | YES | YES |
| L/V orders | NO (waiver possible) | YES | NO | NO |

### 5.5.1. Spacecraft to EGSE umbilical lines

#### 5.5.1.1. Lines definition

Between the base of the payload adapter and the umbilical mast junction box, 92 wires are available for the payload up to 2 min and 35 seconds before lift-off, and 14 wires up to lift-off:

- The 92 umbilical lines pass through the umbilical connector "SHO1" located on the inter-stage section of the Fregat. In case of launch abort after H0 – 2min 35 seconds, these lines will be re-connected in about 2 hours (TBC).
- The 14 umbilical lines pass through a last instant connector "R15" located at the base of the first stage and jettisoned at lift-off. These lines can be assigned to the function related to the spacecraft "switch OFF/ON power" command and telemetry status, which permits the safety configuration to be restored immediately in the event of a launch abort.

#### 5.5.1.2. Lines composition

The spacecraft-to-launch pad rooms (LP room) wiring consists of permanent and customized sections.

The permanent sections have the same configuration for each launch, and consist of the following segments:

- Those between the LP room connectors C1, C2, C3, and C4 and the umbilical connector SHO1 at the top of the mast. This segment is 110 (TBC) meters long.
- Those between the LP room connector C20 and the Fregat interstage section connectors X347 and X348. This segment is 180 (TBC) meters long.

The customized section is configured for each mission. It consists of the following segments:

- The one between the spacecraft interface (J1 and J2) and the connectors SHO1, X347 and X348.
- The one between the LP room connectors C1, C2, C3, C4 and C20, and the Customer COTE in the LP room. The Customer will provide the harness for this segment.

The LV to Launch Pad harness layout is shown in Figure 5-.

A description of these lines and their interfaces is given in Table 5.3.

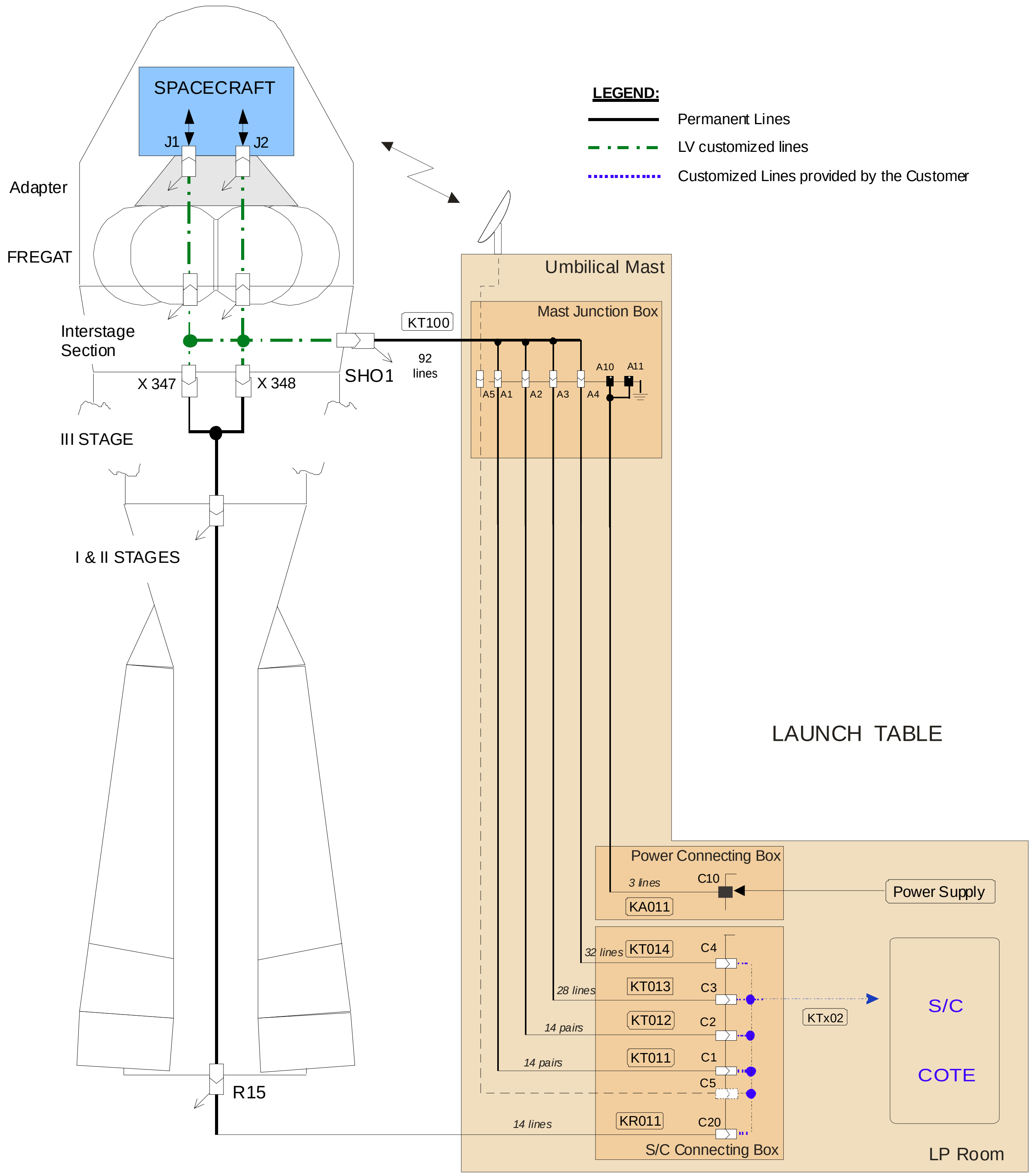



Figure 5-5 - The LV to Launch Pad harness layout

Table 5.3 – Umbilical lines description (TBC).

| Harness designation | Spacecraft electrical signals | Type of Wire Available |
|---|---|---|
| Nominal umbilical lines | | |
| KT011 | Spacecraft power and remote control | 14 (TBC) twisted shielded pairs with a cross section of 2.5 $mm^2$ wired in parallel, thus minimizing voltage losses in the ground harnesses. |
| KT012 | Spacecraft power and remote control | 14 (TBC) twisted shielded pairs with across section of 2.5 $mm^2$ wired in parallel, thus minimizing voltage losses in the ground harnesses. |
| KT013 | Spacecraft check and monitoring | 10 (TBC) twisted shielded pairs with a cross section of 1.0 $mm^2$<br>4 (TBC) twisted shielded pairs with a cross section of 0.20 $mm^2$ and with low capacitance (< 12 nF for 100 m) |
| KT014 | Spacecraft check and monitoring | 16 (TBC) twisted shielded pairs with a cross section of 0.20 $mm^2$ and with a specific impedance (75± 5 Ω) |
| Last instant umbilical lines | | |
| KR011 | 14 spacecraft last instant remote control and check | 4 (TBC) twisted shielded pairs with a specific impedance (75 ± 5 Ω), Gauge 24 for the LV adaptor portion up to the Fregat connection and with a cross section of 0.20 $mm^2$ from the LV adapter / Fregat interface to the EGSE.<br>6 (TBC) single shielded wires with a cross section of 0.35 $mm^2$ from the SC to the connector R15 and a cross section 3 $mm^2$ from the connector R15 to the EGSE |

In case of dual launch these lines are to be shared by both passengers.

#### 5.5.1.3. Electrical Characteristics of the lines

The ground lines are configured to support a permanent current of up to 10 A by wires.

The LV on-board harnesses shall not carry permanent currents in excess of 4 A by wire. The voltage shall be less than 125 Vdc.

The end-to-end resistance of these umbilical links is less than 1.2 Ω between the satellite and its Check-Out Terminal Equipment in LP room and insulation is more than 5 MΩ under 500 Vdc. No current shall circulate in the shielding

It is supposed that the spacecraft wiring insulation is less than 10 MΩ under 50 Vdc. (TBC)

To meet prelaunch electrical constraints, 60 seconds prior to the jettisoning of the umbilical mast and last-instant connectors, all spacecraft EGSE electrical interface circuits shall be designed to ensure no current flow greater 100 mA across the connector interfaces.

#### 5.5.1.4. Additional umbilical lines (Optional)

For mission-specific needs another umbilical connector may be added to the Fregat interstage section. This connector, referred to as SHO5, offers the same service as connector SHO1. To establish this extension, Arianespace will provide a new set of harnesses between the spacecraft and the LP room.

### 5.5.2. L/V to spacecraft electrical functions

The launch vehicle can provide electrical functions used by the spacecraft during flight.

Due to the spacecraft to launch vehicle interface, the Customer is required to protect the circuit against any overload or voltage overshoot induced by his circuits both at circuits switching and in the case of circuit degradation.

To protect spacecraft equipment a safety plug with a shunt on S/C side and a resistance of 2 kΩ ± 1% (0.25 W) on the L/V side shall be installed in all cases.

#### 5.5.2.1. Separation monitoring

The separation status indication is provided by dry loop straps integrated in each spacecraft/LV connectors as follows:

- one dry loop strap per connector (on satellite side) dedicated for the separation monitoring by the upper stage telemetry system.
- dry loop straps (on adapter side) dedicated for the separation monitoring by Satellite if required;

The main electrical characteristics of these straps are:

| | |
|---|---|
| strap "closed": | R ≤ 1 Ω |
| strap "open": | R ≥ 100 kΩ |

#### 5.5.2.2. Dry loop command (Optional)

TBD commands are available.

The main electrical characteristics are:

| | |
|---|---|
| Loop closed: | R ≤ 1 Ω |
| Loop open: | R ≥ 100 kΩ |
| Voltage: | ≤ 32 V |
| Current: | ≤ 0.5 A |

During flight, these commands are monitored by the Fregat telemetry system.

#### 5.5.2.3. Electrical command (Optional)

TBD commands are available with the following main electrical characteristics:

| | |
|---|---|
| Input voltage: | 28 V ± 4 V |
| Input current: | ≤ 0.5 A |
| Number: | 8 |
| Impulse duration | n x (32 ± 0.15) ms (with n: 1 < n < 6) |

These commands are redundant and are monitored by the upper stage telemetry system.

### 5.5.2.4. Spacecraft telemetry retransmission (Optional)

The spacecraft telemetry data can be interleaved with the launch vehicle TM data and retransmitted to the LV ground station by the upper stage telemetry system during the flight.

The data signal characteristics are:

| | |
|---|---|
| Analog low-frequency signals: | 0–6 V |
| Discrete signals with output resistance: | ≤ 1 kΩ in the closed state |
| | ≥ 100 kΩ in the open state |

### 5.5.2.5. Power supply to spacecraft (Optional)

Independent from LV on-board systems, an additional power, without regulation, can be supplied to the spacecraft through specific lines.

The main characteristics are:

| | |
|---|---|
| Input voltage: | 28 V ± 2 V |
| Nominal current: | 1.5 A |
| Capacity: | 120 Ah |

A non-standard voltage can be made available also. The Customer should contact Arianespace for this option.

### 5.5.2.6. Pyrotechnic command (Optional)

The Fregat has the capability to issue all needed and redundant orders to initiate adapter or dispenser separation systems.

In addition to LV orders for spacecraft separation, other pyrotechnic commands can be generated by the Fregat power system to be used for spacecraft internal pyrotechnic system or in case where adapter with separation system is supplied by the Customer. The electrical diagram is presented in Figure 5-.

The main electrical characteristics are:

| | |
|---|---|
| Minimal current: | 4.1 A |
| Nominal current: | 5 A |
| Impulse duration: | 32 msec ± 0.15 msec |
| Nominal battery voltage: | 27 V |
| The redundant order | the same – at the same time |

These orders are supplied from dedicated battery and they are segregated from the umbilical links and other data links passing through dedicated connectors.

This pyro-order is compatible with the initiator 1 A / 1 W / 5 min (TBC), with a resistance of the bridge wire equal to 1.05 Ω ± 0.15 Ω. The one-way circuit line resistance between the Fregat/adapter interface and the spacecraft initiator must be less than 0.22 Ω.

To ensure safety during ground operations, two electrical barriers are installed in the Fregat pyrotechnic circuits. The first barrier is closed 5 seconds before lift-off, and the second one is closed 20 seconds after lift-off.

During flight, the pyrotechnic orders are monitored by the Fregat telemetry system.

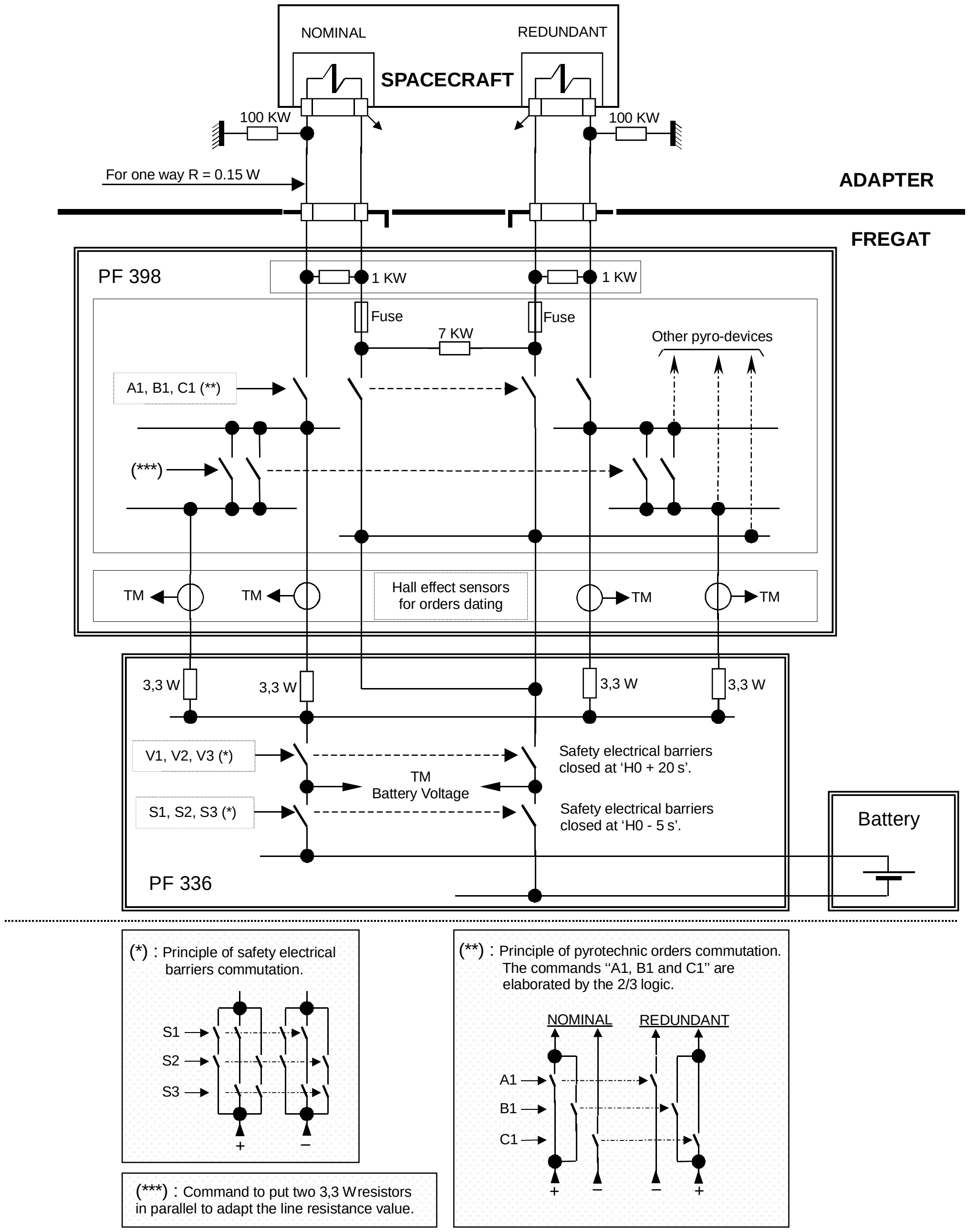



Figure 5-6 Pyrotechnic order – Electrical diagram

### 5.5.3. Electrical Continuity Interface

#### 5.5.3.1. Bonding

The spacecraft is required to have an "Earth" reference point close to the separation plane, on which a test socket can be mounted. The resistance between any metallic element of the spacecraft and a closest reference point on the structure shall be less than 10 mΩ for a current of 10 mA.

The spacecraft structure in contact with the LV (separation plane of the spacecraft rear frame or mating surface of a Customer's adapter) shall not have any treatment or protective process applied which creates a resistance greater than 10 mΩ for a current of 10 mA between spacecraft earth reference point and that of the LV (adapter or upper stage).

#### 5.5.3.2. Shielding

The umbilical shield links are grounded at both ends of the lines (the spacecraft on one side and EGSE on the other). If the Customer desires it is also possible to connect to ground at the umbilical mast connector SHO1 and the last-instant connectors R15. The spacecraft umbilical grounding network diagram is shown in Figure 5-7.

For each LV and ground harnesses connector, two pins are reserved to ensure continuity of the shielding.

### 5.5.4. RF communication link between spacecraft and EGSE

A direct reception of RF emission from the spacecraft antenna can be provided as an optional service requiring additional hardware installation on the fairing and on the launch pad. This option allows users to check the spacecraft RF transmission on the launch pad during countdown. The following configurations are possible:

- Use of radio-transparent windows on the fairing and of a repeater on the launch mast.
- Use of a passive repeater composed of 2 cavity back spiral antenna under the fairing and on its external surface with direct transmission to the spacecraft EGSE.

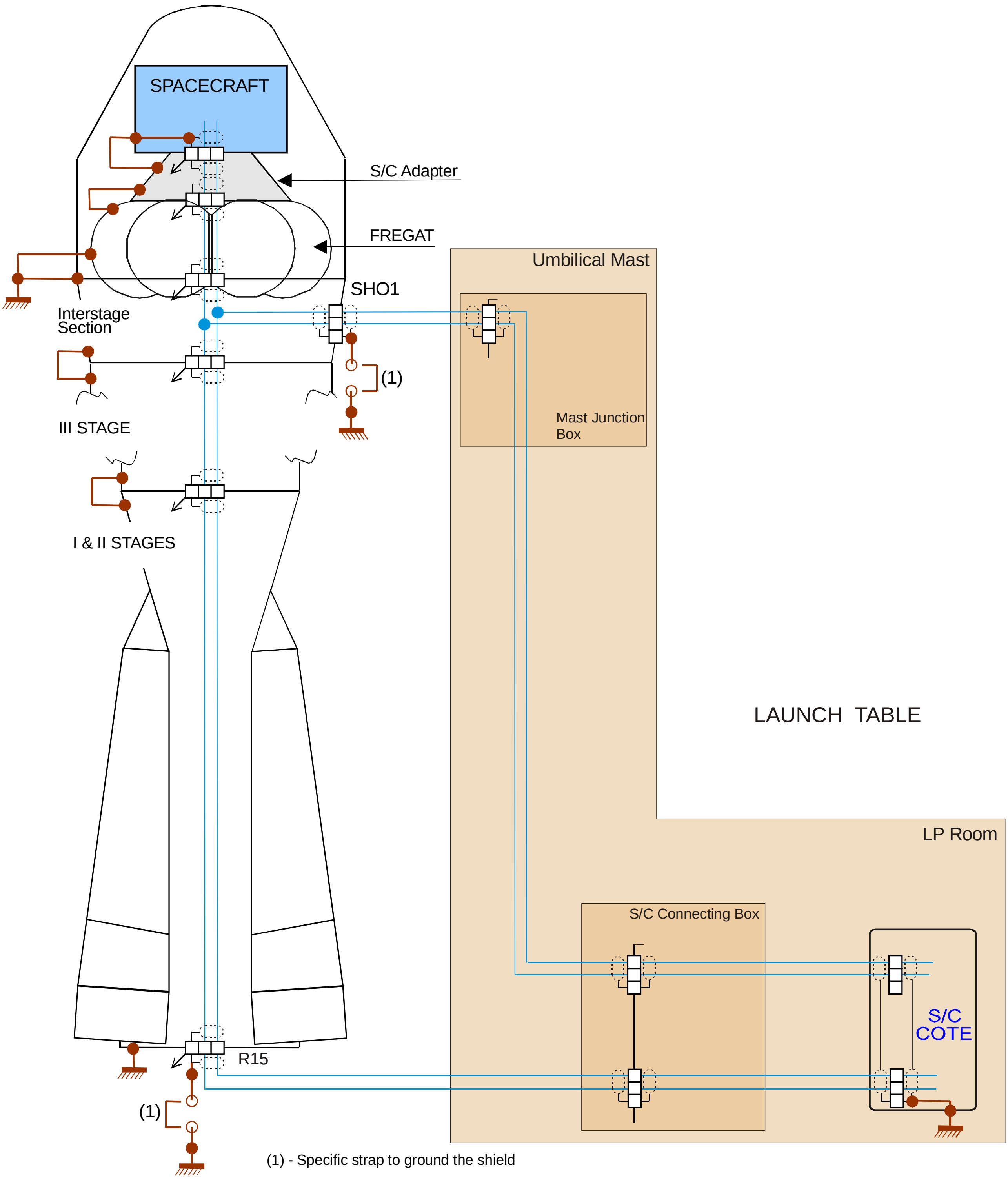



Figure 5-7 – Spacecraft grounding network diagram

## 5.6. Interface verifications

### 5.6.1. Prior to the launch campaign

Prior to the initiation of the launch campaign, the following interface checks shall be performed. Specific LV hardware for these tests is provided according to the contractual provision.

#### 5.6.1.1. Mechanical fit-checks

The objectives of this fit-check are to confirm that the satellite dimensional and mating parameters meet all relevant requirements as well as to verify operational accessibility to the interface and cable routing. It can be followed by a release test.

This test is usually performed at the Customer's facilities, with the adapter equipped with its separation system and electrical connectors provided by Arianespace. For a recurrent mission the mechanical fit-check can be performed at the beginning of the launch campaign, in the payload preparation facilities.

#### 5.6.1.2. Electrical fit-check

Functional interfaces between the spacecraft and the Fregat upper stage (power supply, TM monitoring, commands, etc. if any) shall be checked prior to the beginning of the launch campaign. The customer shall provide an adequate spacecraft electrical interface simulator to be used in the launcher authority's facilities to perform these tests.

### 5.6.2. Pre-launch validation of the electrical I/F

#### 5.6.2.1. Definition

The electrical interface between satellite and launch vehicle is validated on each phase of the launch preparation where its configuration is changed or the harnesses are reconnected. These successive tests ensure the correct integration of the satellite with the launcher and help to pass the non reversible operations. There are three major configurations:

- Spacecraft mated to the adapter;
- Spacecraft with adapter mated to Fregat;
- Upper composite mated to launch vehicle 3$^{rd}$ stage

Depending on the test configuration, the flight hardware, the dedicated harness and/or the functional simulator will be used.

#### 5.6.2.2. Spacecraft simulator

The spacecraft simulator used to simulate spacecraft functions during pre-integration tests and ground patch panel cables will be provided by the Customer.

The electrical interface of the functional satellite simulator shall simulate the spacecraft output/input circuit that communicates with the adapter umbilical lines during validation tests.

It shall be integrated in a portable unit with a weight not higher than 25 kg and dimensions less than 400 × 600 × 400 mm. The simulator can be powered from external source.

#### 5.6.2.3. Spacecraft EGSE

The following Customer's EGSE will be used for the interface validation tests:

- OCOE, spacecraft test and monitoring equipment, permanently located in PPF Control rooms and linked with the spacecraft during preparation phases and launch even at other preparation facilities and launch pad;
- COTE, Specific front end Check-out Equipment, providing spacecraft monitoring and control, ground power supply and hazardous circuit's activation (SPM …).The COTE follows the spacecraft during preparation activity in PPF, HPF and UCIF. During launch pad operation the COTE is installed in the launch pad rooms under the launch table. The spacecraft COTE is linked to the OCOE by data lines to allow remote control.
- set of the ground cables for satellite verification

The installation interfaces as well as environmental characteristics for the COTE are described in the Chapter 6.

# GUIANA SPACE CENTRE — Chapter 6

## 6.1. Introduction

### 6.1.1. French Guiana

The Guiana Space Centre is located in French Guiana, a French Overseas Department (D.O.M.). It lies on the Atlantic coast of the Northern part of South America, close to the equator, between the latitudes of 2° and of 6° North at the longitude of 50° West.

It is accessible by sea and air, served by international companies, on regular basis. There are flights every day from and to Paris, either direct or via the West Indies. Regular flights with North America are available via Guadeloupe or Martinique.

The administrative regulation and formal procedures are equivalent to the one applicable in France.

The climate is equatorial with a low daily temperature variation, and a high relative humidity.

The local time is GMT – 3 h.

Figure 6.1 - The French Guiana on the map

### 6.1.2. The European spaceport

The European spaceport is located between the two towns of Kourou and Sinnamary and is operational since 1968.

The CSG is governed under an agreement between France and the European Space Agency and the day to day life of the CSG is managed by the French National Space Agency (Centre National d'Etude Spatiales – CNES) on behalf of the European Space Agency.

The CSG mainly comprises:

- **CSG arrival area** through the sea and air ports (managed by local administration);
- **The Payload Preparation Complex** (Ensemble de Preparation Charge Utile – EPCU) shared between three launch vehicles,
- **Upper Composite Integration Facility** (UCIF) dedicated to each launch vehicle
- The dedicated **Launch Sites** for Ariane, Soyuz and Vega each including Launch Pad, LV integration buildings, Launch Centre (CDL, "Centre de Lancement") and support buildings,
- **The Mission Control Centre** (MCC or CDC – "Centre de Controle")

The Soyuz Launch Site (Ensemble de Lancement Soyuz – ELS) is located some 10 km North West of the existing Ariane 5 launch facilities (ELA3) and of the future Vega launch facilities installed in place of the previous ELA1. The respective location is shown in Figure 6.2.

General information concerning French Guiana, European Spaceport, Guiana Space Center (CSG) and General Organization are presented in the presentation of Satellite Campaign Organisation, Operations and Processing (CD-ROM SCOOP, 2003).

Buildings and associated facilities available for spacecraft autonomous preparation are described in the Payload Preparation Complex (EPCU) User's Manual (Issue 8.0, 2003, available also on CD-ROM).

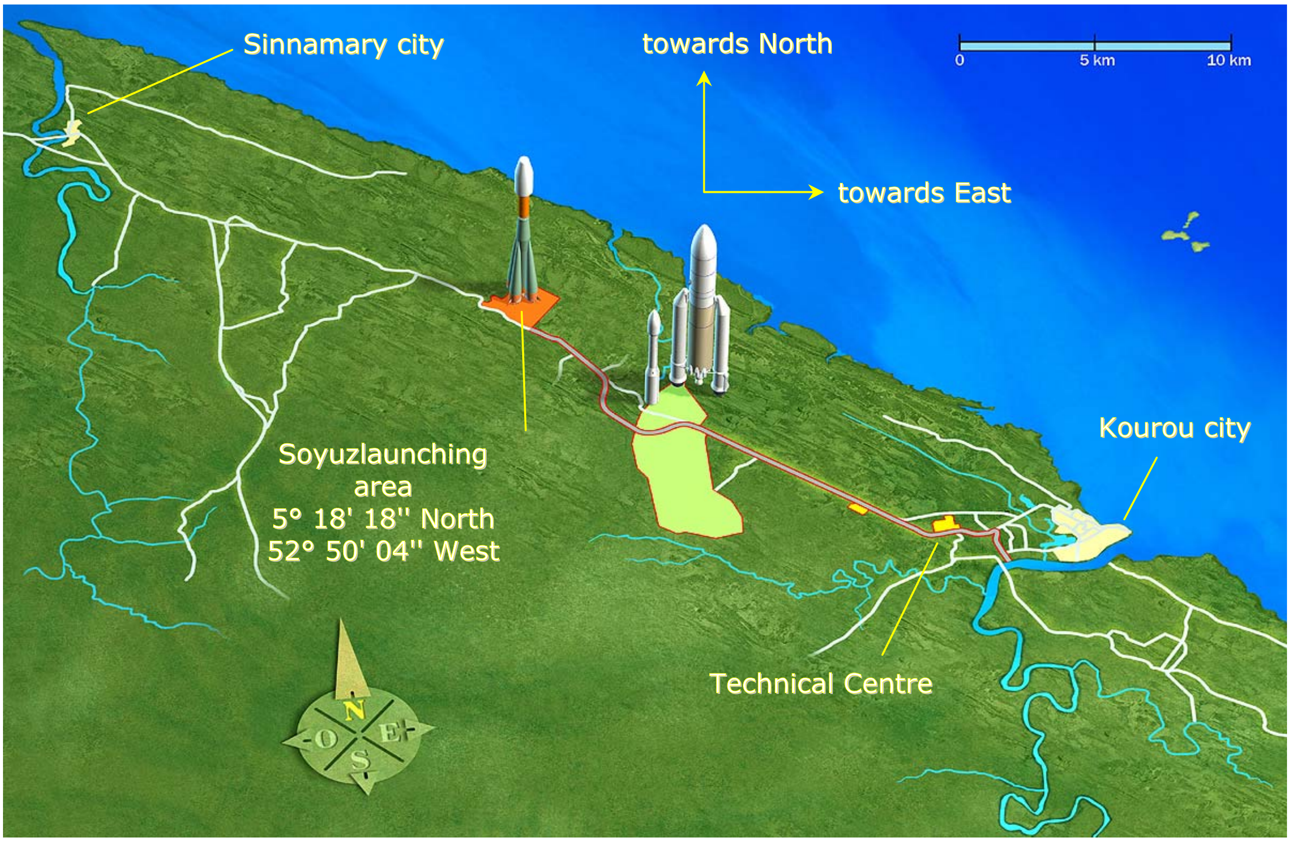



Figure 6.2 –The Guiana Space Centre

## 6.2. CSG GENERAL PRESENTATION

### 6.2.1. Arrival areas

The spacecraft, Customer's ground support equipment and propellant can be delivered to the CSG by aircraft, landing at Rochambeau international airport, and by ship at the Cayenne Pariacabo for "commercial" ships and Pariacabo harbor for Arianespace's ships that can be used also for spacecraft delivery. Arianespace provides all needed support for the equipment handling and transportation as well as formality procedures.

#### 6.2.1.1. Rochambeau international airport

Rochambeau international airport is located near Cayenne, with a 3200 meters runway adapted to aircraft of all classes and particularly to the Jumbo-jets:

- B 747
- C 130
- Antonov-124

A wide range of horizontal and vertical handling equipment is used to unload and transfer standard type pallets/containers.

Small freight can be shipped by the regular Air France B747 cargo weekly flight.

A dedicated Arianespace office is located in the airport to welcome all participants arriving for the launch campaign and to coordinate the shipment procedures.

The airport is connected with the EPCU by road, about 75 kilometers away.

#### 6.2.1.2. Cayenne harbour

Cayenne harbor is located in the south of the Cayenne peninsula in Degrad des Cannes. The facilities handle large vessels with less than 6 meters draught.

The harbor facilities allow the container handling in Roll-On/Roll-Off (Ro-Ro) mode or in Load-On/Load-Off (Lo-Lo) mode. A safe open storable area is available at Dégrad-des-Cannes.

The port is linked to Kourou by 85 km road.

#### 6.2.1.3. The Pariacabo docking area

The Pariacabo docking area is located on the Kourou river, close to Kourou City. This facility is dedicated to the transfer of the launcher stages and/or satellites, by Arianespace ships and is completely under CSG responsibility.

The area facilities allow the container handling in Roll-On/Roll-Off (Ro-Ro) mode.

The docking area is linked to EPCU by a 9 km road.

### 6.2.2. Payload preparation complex (EPCU)

The Payload Preparation Complex (EPCU) is used for spacecraft autonomous launch preparation activities up to integration with the launch vehicle and including spacecraft fuelling. The EPCU provides wide and redundant capability to conduct several simultaneous spacecraft preparations thanks to the facility options. The specific facility assignment is finalized, usually, one month before spacecraft arrival.

The Payload Preparation Complex consists of 4 major areas and each of them provides similar capabilities:

- **S1,** Payload Processing Facility (PPF) located at the CSG Technical Centre;
- **S3,** Hazardous Processing & Upper Composite Integration Facilities (HPF/UCIF)) located near to the ELA3;
- **S2-S4,** Hazardous Processing Facilities (HPF) for pyro-devices located near to the ELA3
- **S5,** Payload/Hazardous processing facilities (PPF/HPF)**;**

The complex is completed by auxiliary facilities: the Propellant Storage Area (ZSE), Pyrotechnic Storage Area (ZSP) and chemical analysis laboratory located near the different EPCU buildings.

All EPCU buildings are accessible by two-lane tarmac roads, with maneuvering areas for trailers and handling equipment

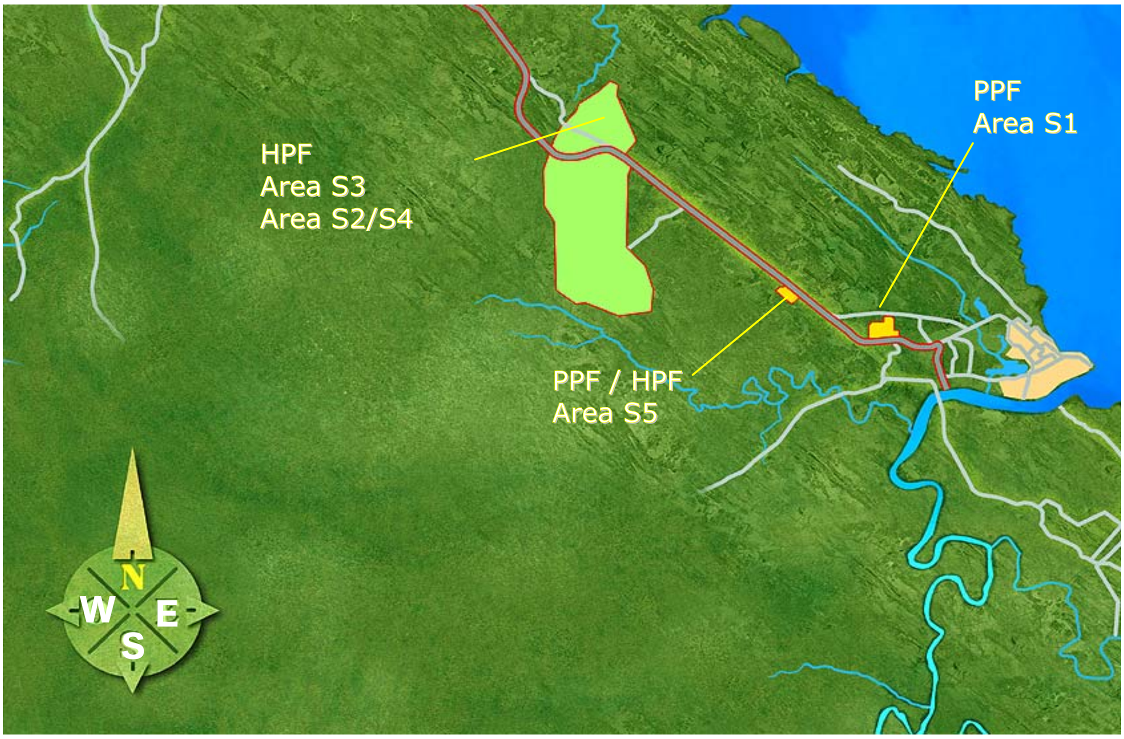



Figure 6.3 – Payload Preparation Complex (EPCU) location

#### 6.2.2.1. S1 Payload Processing Facility

The S1 Payload Processing Facility consist of buildings intended for the simultaneous preparation of several spacecraft. It is located on the north of the CSG Technical Centre close to Kourou town. The area location, far from the launch pads ensures unrestricted all-the-year-round access.

The area is completely dedicated to the Customer launch teams and is use for all non-hazardous operations.

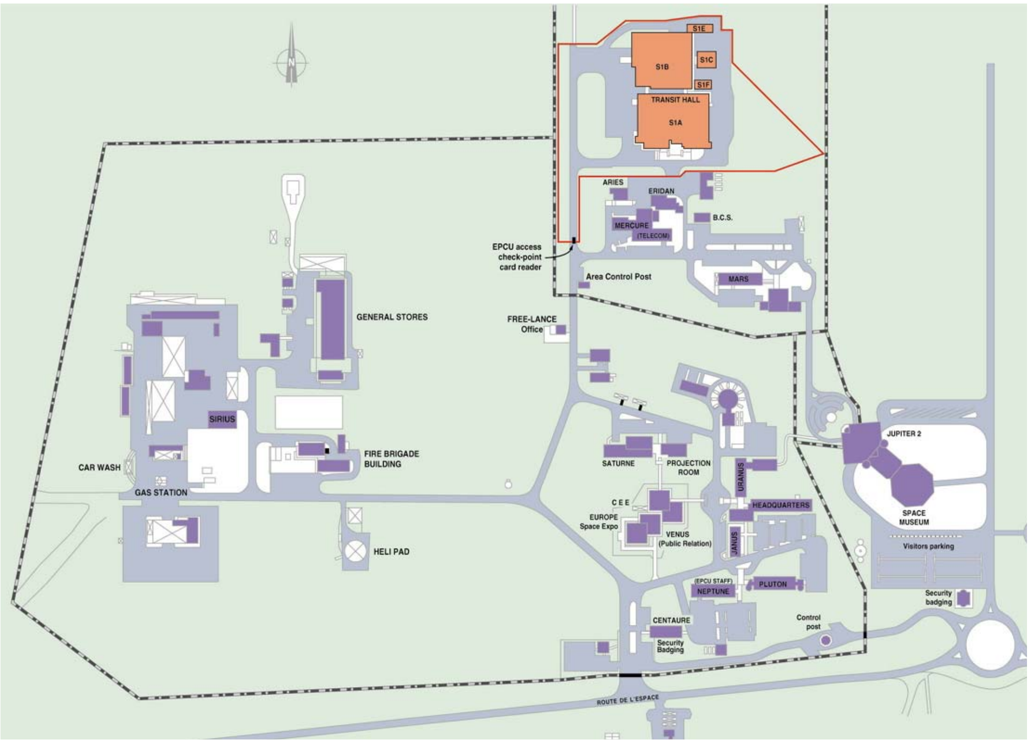



Figure 6.4 – S1 Area layout

The facility is composed of 2 similar main buildings comprising one clean room each, separated building for offices, laboratory and storage areas. The passage between buildings is covered by a canopy for sheltered access between the buildings. The storage facility can be shared between buildings.


Figure 6.5 – S1 area composition

**The S1A is building** composed of 1 clean high bay of 490 m$^2$ that can be shared by two payloads ("Western" and "Eastern" areas) and rooms and laboratories including 3 control room and storage areas.

**The S1B building** is composed of 1 clean high bay of 860 m$^2$ that could be shared by two spacecraft ("Northern" and "Southern" areas) and rooms and storage areas including 4 control rooms. Offices are available for spacecraft teams and can accomodate around 30 persons.

**The S1C, S1E and S1F buildings** provide extension of the S1B office space. The standard offices layout allows to accommodate around 30 persons.

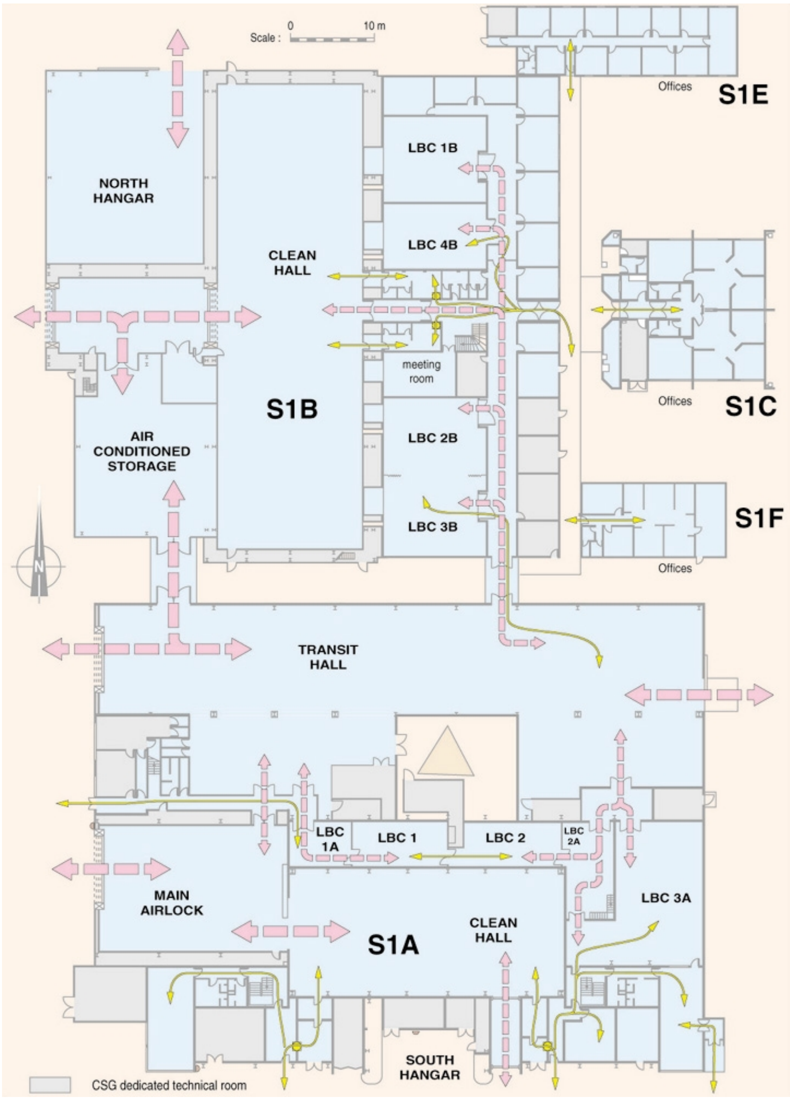



Figure 6.6 – S1 layout

### 6.2.2.2. S3 Hazardous & UC Integration Facility

The S3 Hazardous & Upper Composite Integration Facilities consists of buildings used for different hazardous operations, basically, fuelling of mono and/or bipropellant, and integration of solid propellant apogee kick-off motors.

For Soyuz LV these facilities will be used also for the final spacecraft encapsulation under the fairing (see paragraph 6.2.3.1).

The area is located on the south-west of the Ariane-5 launch pad (ZL3), fifteen kilometers from the CSG Technical Centre (CT). The area close location to the Ariane and Vega launch pads imposes precise planning of the activity conducted in the area.

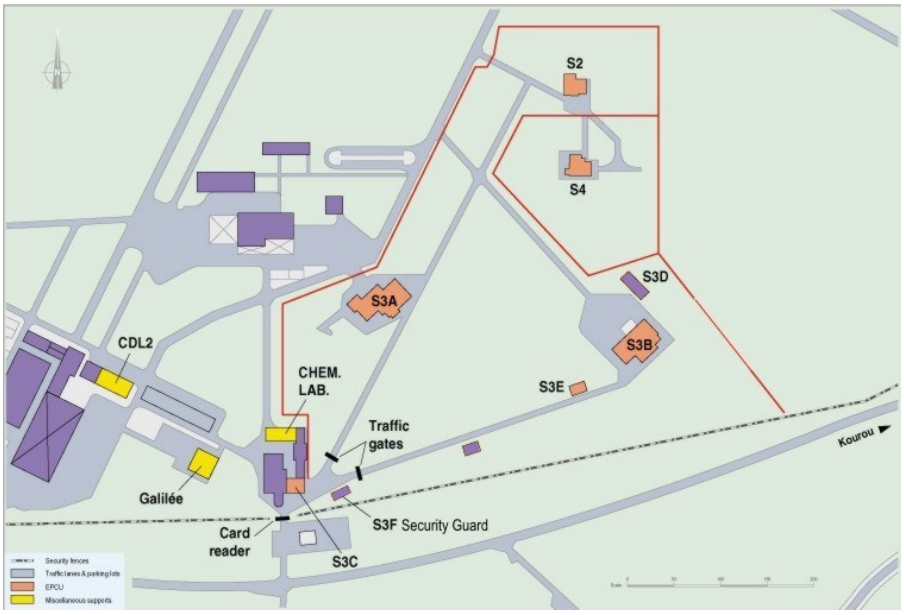



Figure 6.7 – S3 area map


Figure 6.8 – S3 area overview

The Customer's facility includes three separated building S3A, S3C, S3E.

**The S3A building** is dedicated to the middle-class spacecraft main tanks and attitude control system fuelling, integration with solid motors, weighing, pressurization and leakage tests as well as final spacecraft preparation and integration with adapter. The building is mainly composed of two Fuelling Halls of 110 $m^2$ and 185 $m^2$, and one Assembly Hall of 165 $m^2$.

**(The S3B building** is used as Upper Composite Integration Facility, see 6.2.3.1)

**The S3C building** is dedicated to the remote monitoring of the hazardous operations in the S3A and S3B, as well as housing of the satellite team during these operations. The building is shared with the safety service and Fire brigade. The Customer's part of the building is composed of meeting room and offices.

**The S3E building** is used by the spacecraft teams to carry out the passivation operations of the spacecraft propellant filling equipment and decontamination. It is composed of one externally open shed of 95 $m^2$.


Figure 6.9 – Layout of Hazardous and Upper Composite Integration Facilities at S3 area (S3A and S3B)

### 6.2.2.3. S5 Payload Processing & Hazardous Facility

The S5 Payload & Hazardous Processing Facility consists of a few clean rooms, fueling rooms and offices connected by environmentally protected corridors. It is safely located on the south-west bank of the main CSG road, far from launch pads and other industrial sites providing all-the-year-round access.

EPCU S5 enables an entire autonomous preparation, from satellite arrival to fuelling taking place on a single site. The building configuration allows for up to 4 spacecraft preparations simultaneously, including fueling, and in the same time, provides easy, short and safe transfers between halls.


Figure 6.10 – PPF/HPF S5 area overview

The main facility is composed of 3 areas equipped by airlocks and connected by two access corridors:

**the S5C area**, dedicated to the spacecraft non-hazardous processing and to the launch team housing is mainly composed of 1 large high bay of 700 $m^2$ that can be divided in 2 clean bays, 4 control rooms and separated office areas.

**the S5A area**, dedicated to spacecraft fuelling and other spacecraft hazardous processing, is mainly composed of 1 clean high bay of 300 $m^2$.

**the S5B area**, dedicated to fuelling large spacecraft and other spacecraft hazardous processing and is mainly composed of 1 clean high bay of 410 $m^2$.

The three halls, transfer airlocks and the access corridors have a class 100,000 cleanliness. The satellite is transported to the different halls on air cushions or trolleys.

In addition to the main facility, the S5 area comprises the following buildings:

- **S5D**, dedicated to final decontamination activities of satellite fuelling equipment,
- **S5E**, dedicated to the preparation of SCAPE suits and training, dressing ,and cleaning of propulsion teams.

The entrance to the area is secured at the main access gate.

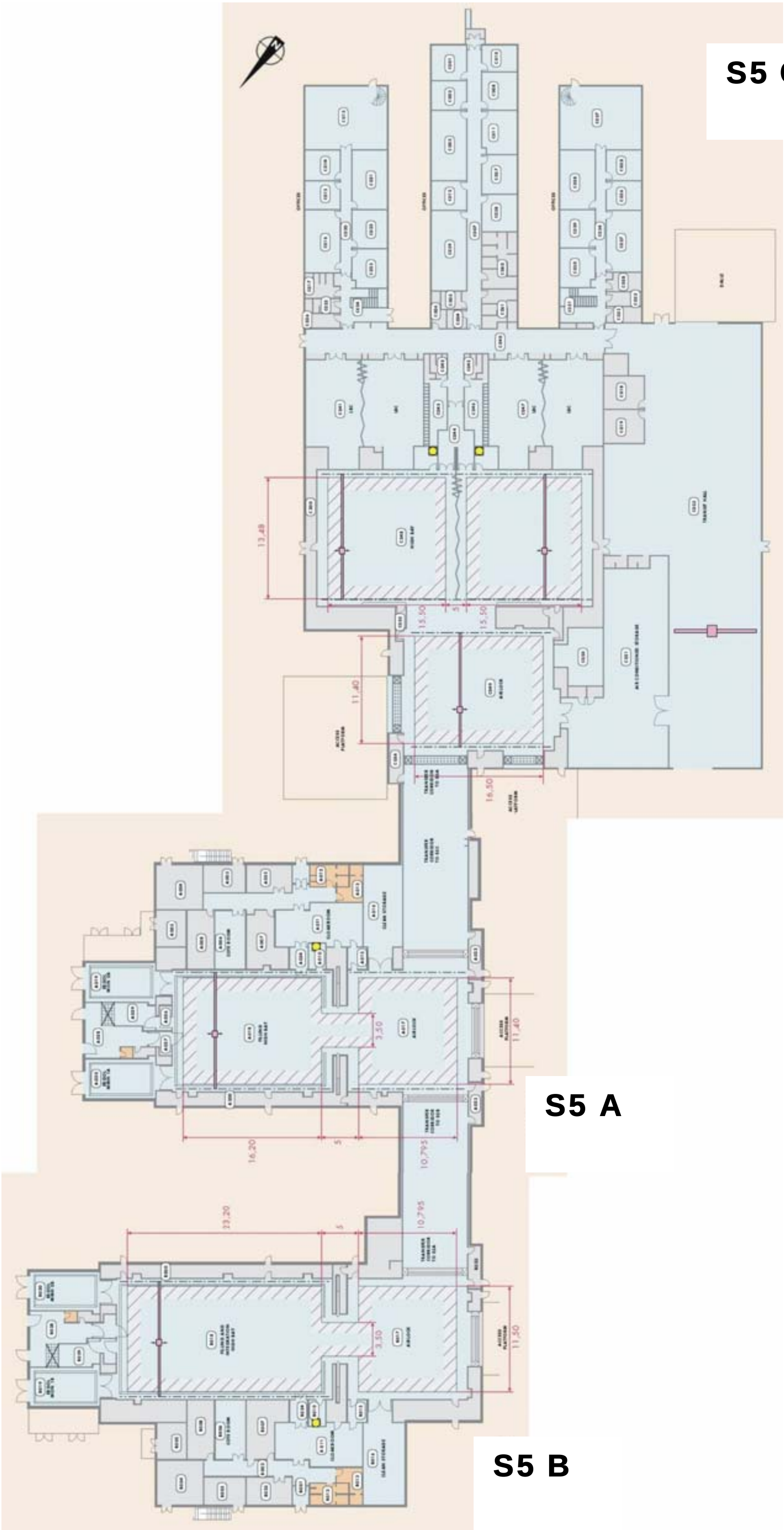



Figure 6.11 - PPF/HPF S5 layout

## 6.2.3. Facilities for combined and launch operations

### 6.2.3.1. UCIF

The building S3B of the S3 area will be used as the Upper Composite Integration Facility. In the building the following operations will be performed:

- spacecraft and adapter/dispenser integration on the Fregat upper stage, and
- encapsulation under the fairing in vertical position.

The dimensions of the hall are properly sized for the integration activity. The area is about 20 × 20 m and there is 19 m under the rail of the crane. The airlock door dimensions are 6 × 18 m.

Specific operations can be controlled from the control rooms on S3C building.

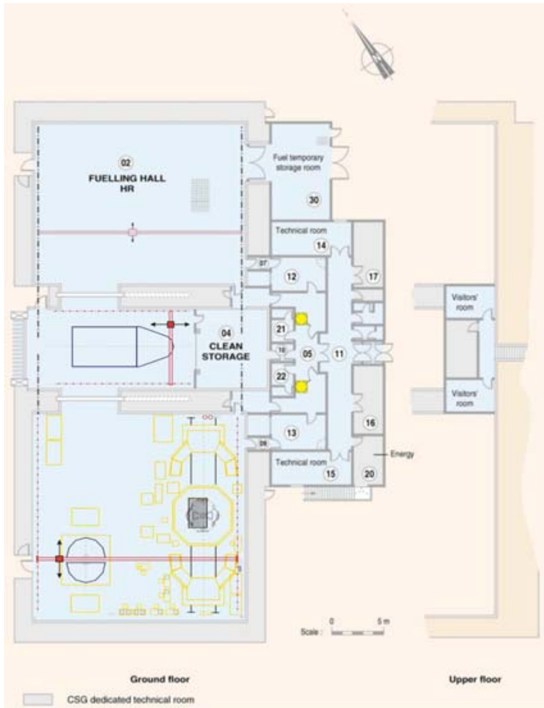



Figure 6.12 – The S3B layout in UCIF configuration

### 6.2.3.2. Soyuz Launch Site (ELS « Ensemble de Lancement Soyuz »)

The Soyuz launch site is a dedicated area designed for launch vehicle final preparation, the upper composite integration with launch vehicle and final launch activities. It includes the Launch Pad ("Zone de Lancement" - ZL), the LV integration building (MIK), the Launch Control Building (CDL, "Centre De Lancement") and support buildings see Fig. 6.15.

*6.2.3.2.1. LV Integration Building (MIK)*

The MIK is used for the LV's 3-stages and Fregat upper stage storage, assembling and test. The building is similar to the one used in Baikonur and Plesetsk.

No spacecraft or combined operations are conducted in this building.

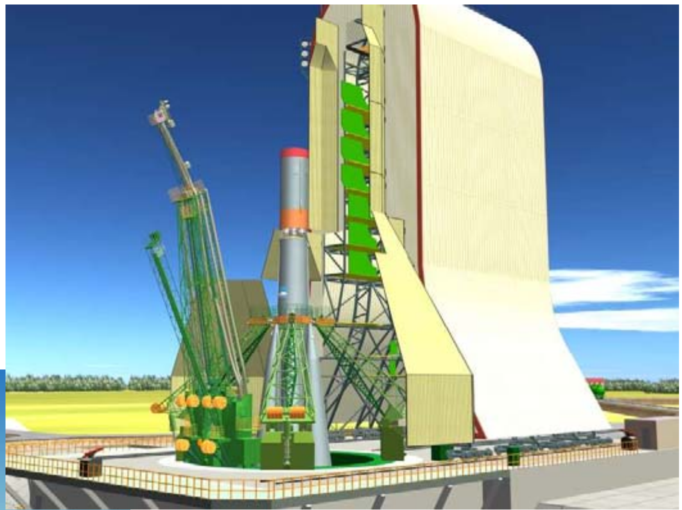
*6.2.3.2.2. Launch Pad*

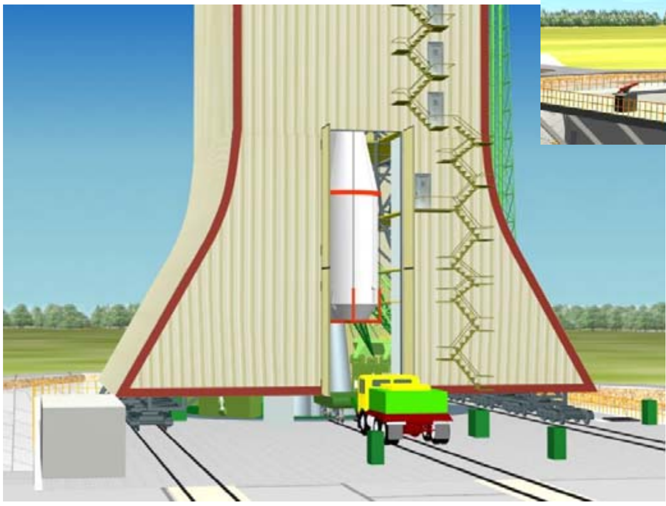
The launch pad consists of the metallic support structure integrated with the concrete launch table equipped with the support arms ("start system"), and a mobile servicing gantry, used for launch vehicle preparation, integration with the upper composite and launch.

The support arms and launch table servicing equipment are identical to the other Soyuz launch pads used in Baikonur and Plesetsk.

The mobile servicing gantry is equipped with a ceiling traveling crane for upper composite installation. The mobile servicing gantry protect from the outside environment and constitute a protected room for all activity with the upper composite and satellite.

3-Stage Soyuz on launch pad





Payload composite hoisting on Launch Vehicle

6.13 – Soyuz Launch Pad and Servicing gantry

The ground/board electrical connection is performed at the Fregat interstage section by a dedicated umbilical mast.

The launch tower is equipped with an air-conditioning system providing clean air under the fairing.

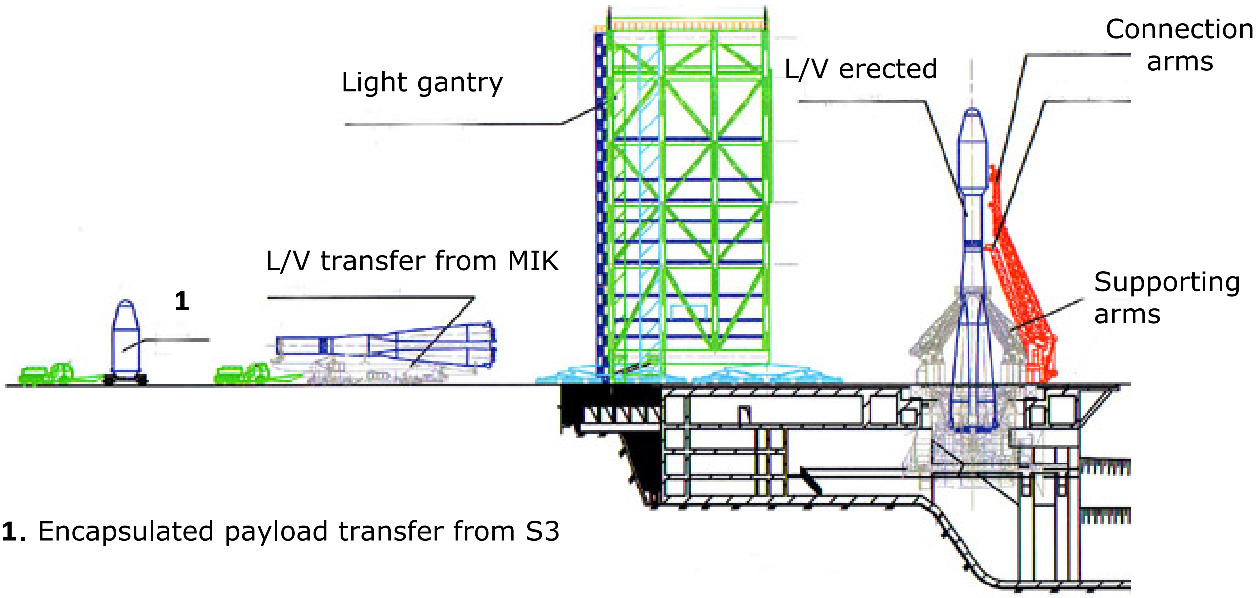



Figure 6.14 – Soyuz Launch Pad

Two launch pad Customer's rooms for accommodation of Customers' check-out terminal equipment (COTE) are located under the launch table at the level – 5.4 m.

Details of anti-sismic racks installation and interfaces can be obtained from Arianespace. Up to 2 anti-sismic racks can be provided by Arianespace.

The equipments installed in the COTE are to be qualified either in acoustic or random wrt the following levels:

- Acoustic

| Octave bands (Hz) | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | Overall |
|---|---|---|---|---|---|---|---|---|
| Qualification level (dB) | 133 | 132 | 128 | 126 | 123 | 122 | 118 | 137 |

Time duration: 1 minute

- Random

| Bandwidth | Overall level (g eff) | PSD | Time duration |
|---|---|---|---|
| 20 - 2000 | 12 | 0.0727 | 1 minute on 3 axes |

The rooms are protected from the environment generated by the launch vehicle at lift-off and they are not accessible during the launch.

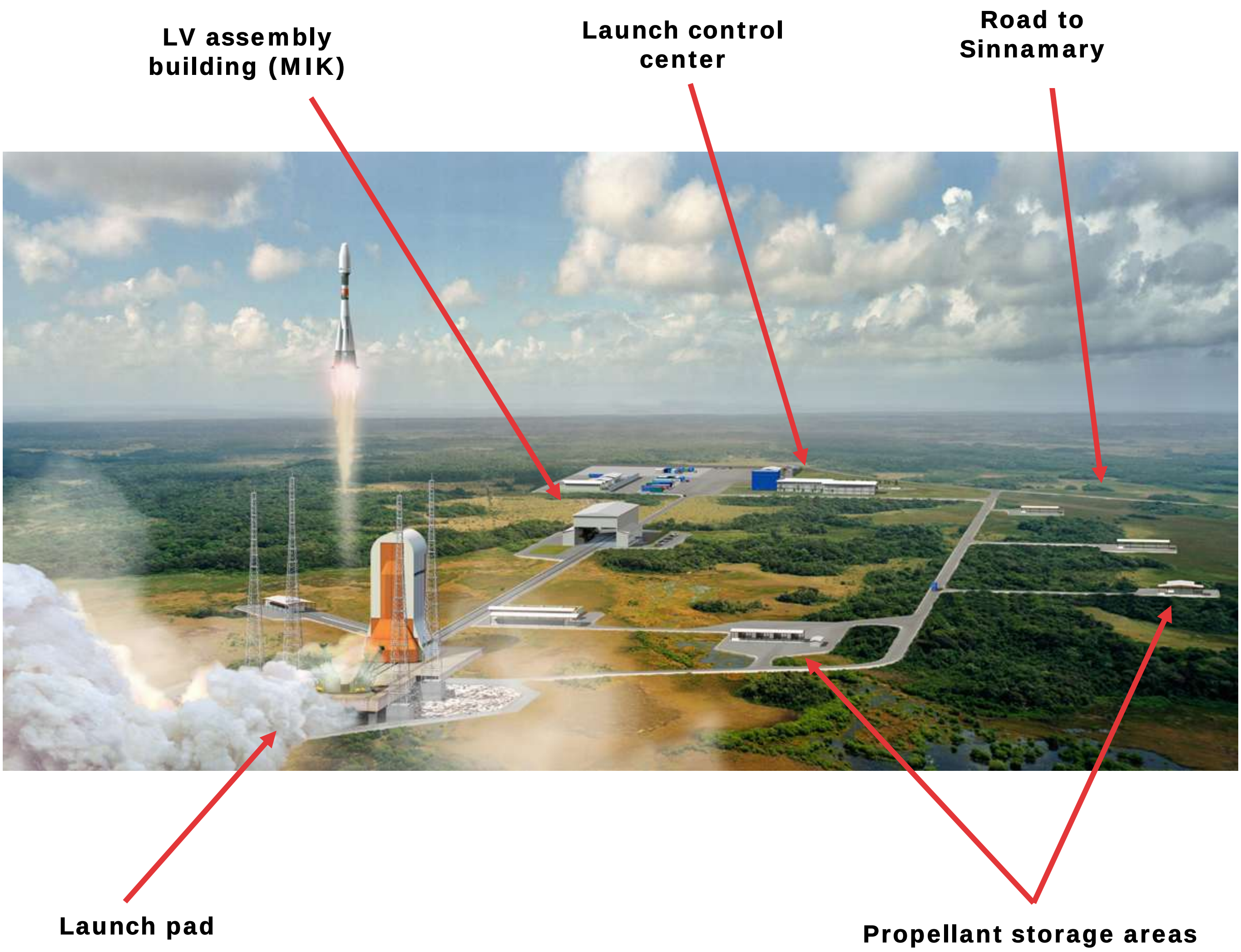



Figure 6.15 – Soyuz Launch Site


Figure 6.16 – Launch Pad overview

*6.2.3.2.3. Launch Centre (CDL)*

The Launch Centre which is located TBD km from the launch pad, and houses the launch vehicle operational team, launch desk, and launch pad monitoring equipment.

The Launch Centre is used by the launch vehicle operational team for managing of the final launch preparation and launch and monitoring the health of the LV and LV's and launch pad readiness for the launch. The Launch Centre is integrated in the CSG operational communication network providing capabilities to act as one of the entity affecting countdown automatic sequence.

### 6.2.3.3. Mission Control Centre – Technical Centre

The main CSG administrative buildings and offices, including safety and security service, laboratories, CNES, ESA representative offices are located in the Technical Centre. Its location, a few kilometres from Kourou on the main road to the launch pads, provides the best conditions for management of all CSG activity.

Along with functional buildings the Technical Centre houses the Mission Control Centre located in the Jupiter building. The Mission Control Centre is used for:

- Management and coordination of final prelaunch preparation and countdown.
- Processing of the data from the ground telemetry network;
- Processing of the readiness data from the launch support team (meteo, safety …)
- Providing the data exchange and decisional process with Go-No/Go criteria;
- Flight monitoring

The spacecraft launch manager or his representatives stay in the Mission Control Centre during prelaunch and launch activities, and, if necessary can stop the countdown (see Chapter 7.5.5.5.4.).

The Customer will have up to 3 operator's seats, 1 monitoring place and room and visitors seats for other Customer's representatives.

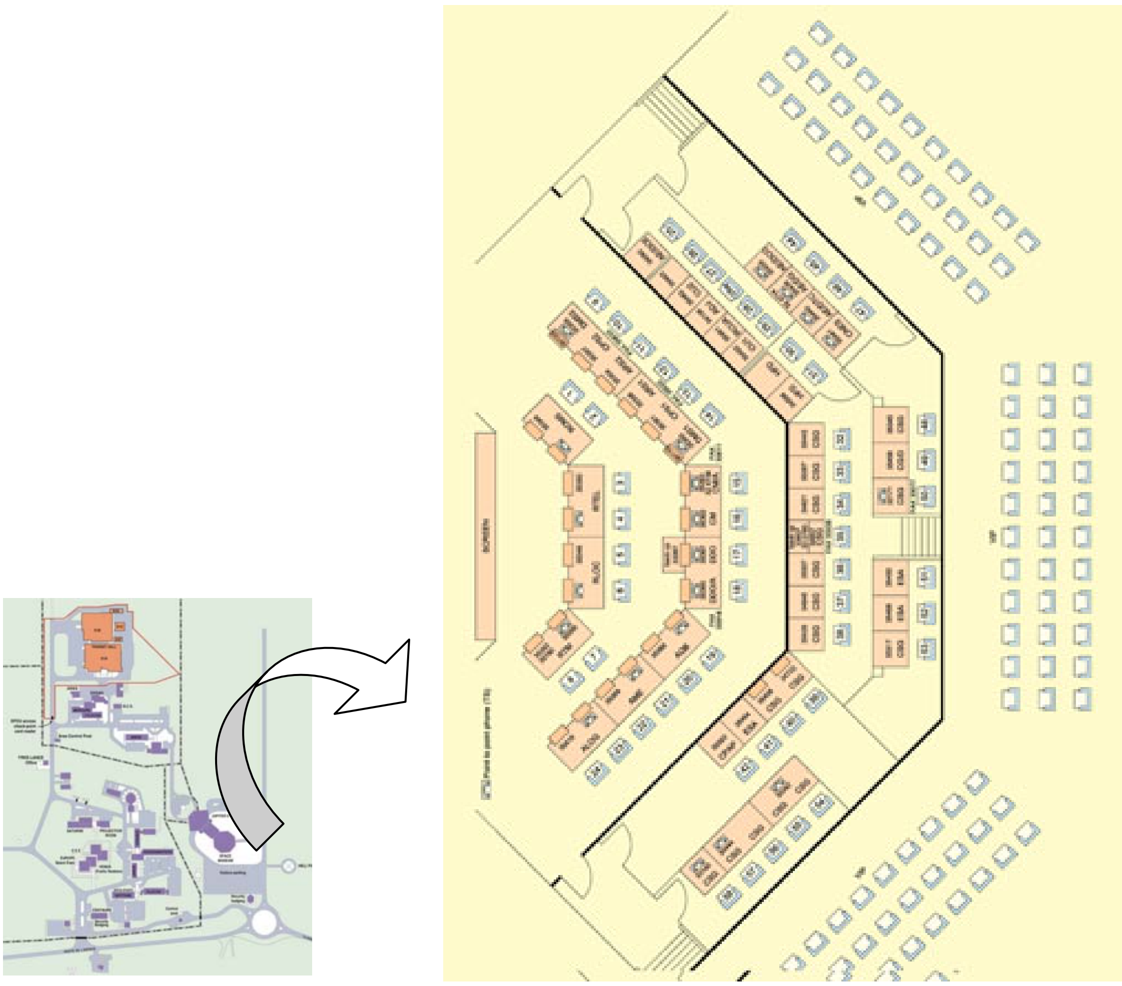


Figure 6.17 – Mission Control centre (Jupiter II)

## 6.3. CSG GENERAL CHARACTERISTICS

### 6.3.1. Environmental Conditions

#### 6.3.1.1. Climatic conditions

The climatic conditions at the Guyana Space Centre are defined as follows:

- The ambient air temperature varies between: 18°C ≤ T ≤ 35°C
- The relative humidity varies between: 60% ≤ r ≤ 100%.

#### 6.3.1.2. Temperature / Humidity and Cleanliness in the facilities

Data related to the environment and cleanliness of the various working areas are given in Table 6-1.

Table 6-1 – The temperature/humidity and cleanliness in the facilities

| Designation | Particle Cleanliness | Organic Cleanliness | Temperature | Relative Humidity |
|---|---|---|---|---|
| PPF , HPF and UCIF (S3) clean halls | Class 8 (100,000*) | ESA standard** | 23°C ± 2°C | 55% ± 5% |
| HPF (S2-S4) halls | N/A | N/A | 23°C ± 2°C | N/A |
| CCU container | Class 8 (100,000*) | ESA standard** | CCU2 < 27°C<br>CCU3 23°C ± 2°C | 55% ± 5% |
| LP tower room TBD | - | - | <27°C | - |
| Customer LP room | N/A | N/A | TBD | TBD |

Note:

* According to the US Federal Standard 209D.

* According to the AE GRCO–36 Issue 0/Rev.0, December 2000 (pollution < $2.10^{-7}$ g/cm$^2$/week).

Atmospheric pressure in the EPCU buildings is 998 mbar ≤ $P_{atm}$ ≤ 1023 mbar

#### 6.3.1.3. Mechanical Environment

No specific mechanical requirements are applicable during the activity at the CSG except during transportation and handling.

During transport mainly by cars and handling of the non-flight hardware and support equipment as well as spacecraft in its container the following dimensioning loads at the interface with platform shall be taken into account:

- Longitudinal QSL (direction of motion): ± 1g
- Vertical QSL (with respect to the Earth): 1g ± 1g
- Transverse: ± 0.4g

Details on the mechanical environment of the spacecraft when it is removed from its container are given in Chapter 3.

### 6.3.2. Power Supply

All facilities used by the Customer for spacecraft activity during autonomous and combined operations are equipped with an uninterrupted power supply category III.

For non-critical equipment like general lighting, power outlets, site services, etc. a public network (220 V/50 Hz) Category I is used.

Category II is used for the equipment which must be independent from the main power supply, but which can nevertheless accept the fluctuation (a few milliseconds) or interruptions of up to 1 minute: gantries, air conditioning, lighting in hazardous and critical areas, inverter battery charger, etc.

The category III is used for critical equipment like S/C EGSE, communication and safety circuits, etc.

The CSG equipment can supply current of European standard (230V/380V - 50 Hz) or US standard (120V/208V - 60 Hz).

More detailed characteristics of the power network are presented in the EPCU User's Manual.

### 6.3.3. Communications Network

#### 6.3.3.1. Operational data network

The existing CSG network will extend its capability to cover new Soyuz facility and will provide the same level of quality.

Data links are provided between the Customer support equipment located in the different facilities and spacecraft during preparation and launch. The Customer OCOE in the PPF Control room is connected with the satellite and COTE in the HPF, UCIF, LP Customer room (catacomb), Launch Centre, and Mission Control Centre (DMS/CPS Console at Jupiter 2). The Customer is responsible for providing correct signal characteristics of EGSE to interface with the CSG communication system.

Customer data transfer is managed through the MULTIFOS system (MULTIplex Fibres Optiques Satellites) based on TBD dedicated optical fiber links. Three main dedicated subsystems and associated protected networks are available.

**STFO** ("Système de Transmission par Fibres Optiques")

Transmission of TM/TC between Customer's EGSE and satellite can be performed as follows:

- RF signals in S, C, and Ku frequency band
- Base band digital: rate up to 1 Mb/s signals
- Base band analog: rate up to 2 Mb/s signals

**ROMULUS** ("Réseau Opérationnel MULtiservice à Usage Spatial)

Transmission of operational signals between Customer EGSE located in PPF and Mission Control Centre, DMS console (Green/Red status).

**PLANET** (Payload Local Area NETwork)

PLANET provides Customer with dedicated Ethernet VLAN type 10 Mb/s network. This network is set-up and managed by CSG: 3 VLAN networks are available per Customer and can be accomodated according to Customer's request for operational data tranfer between EGSE and satellite and/or for inter-offices connections between personal computers.

Encrypted data transfer is also possible.

Dedicated stripped ends optical fibers are also available in PPF low bays for EGSE connectors at one side, in HPF, and in the launch pad Customer room for COTE connection at the other end.

For confidentiality purpose, Customers can connect their equipment at each part of these direct and point-to-point dedicated optical fibers.

TO BE ISSUED LATER

Figure 6.18 – Typical operational data network configuration

### 6.3.3.2.Range communication network

The multifunctional range communication network provides Customer with different ways to communicate internally at CSG, and externally, by voice and data, and delivers information in support of satellite preparation and launch.

The following services are proposed in its standard configuration or adapted to the Customer needs:

**CSG Telephone PABX System (CTS)**

Arianespace provides specified numbers of telephone and fax equipment for voice and data transmission through the CSG local phone network with PABX Commutation Unit.

**Public external network**

The CSG Telephone System (CTS) is commutated with external public network of France Telecom including long-distance paid, ISDN calls opportunities and access.

The GSM system cellular phones are operational at CSG through public operator providing roaming with major international operator.

**Direct or CSG PABX relayed external connection**:

- <u>Connection to Long Distance Leased lines (LL)</u>

  The Customer could subscribe at external provider for the Long Distance Leased lines or satellite –based communication lines. These lines will be connected to the CSG PABX Commutation Unit or routed directly to the Customer equipment. For the satellite –based communication lines the antennas and decoder equipment will be supplied by Customer.

- <u>PABX Relay lines connection (LIA)</u>

  On Customer request, the Long Distance Leased lines or satellite –based communication lines could be relayed with other PABX communication network providing permanent and immediate exchange between two local communication systems.

- <u>Connection to the point-to-point external data lines</u>

  In addition to the Long Distance Phone Leased lines the Customer may extend the subscription for the lines adapted to the data transmission. They could be connected to the CSG PABX through the specific terminal equipment or to the LAN.

**CSG Point-to-Point Telephone System (TS):**

A restricted point-to-point telephone network (TS) can be used mainly during launch pad operations and countdown exclusively by Customer appointed operational specialists. This network is modular and can be adapted for specific Customer request. These telephone sets can only call and be called by the same type of dedicated telephone sets.

**Intercommunication system (Intercom):**

- <u>Operational intersite Intercom system (IO)</u>

The operational communication during satellite preparation and launch is provided by independent Intercom system with a hosts at each EPCU facility. This system allows full-duplex conversations between fixed stations in various facilities, conference and listening mode, and switch to the VHF/UHF fuelling network (IE). All communications on this network are recorded during countdown.

- <u>The dedicated Intercom for hazardous operations (IE)</u>

The restricted independent full-duplex radio system is available between operator's suits and control rooms for specific hazardous operations such as filling. By request this system could be connected to the Operational Intercom (OI).

**VHF/UHF Communication system**

The CSG facilities are equipped with a VHF/UHF network that allows individual handsets to be used for the point-to-point mobile connections by voice.

**Paging system**

CSG facilities are equipped with a paging system. Beepers are provided to the Customers during their campaign.

**Videoconference communication system**

Access to the CSG videoconference studios, located in the EPCU area, is available on Customer specific request.

#### 6.3.3.3. Range information systems

**Time distribution network**

The Universal Time (UT) and the Countdown Time (TD) signals are distributed to the CSG facilities from two redundant rubidium master clocks to enable the synchronization of the check-out operations. The time coding is IRIG B standard accessed through BNC two-wire connectors or RJ 45 plugs.

**Operational Reporting Network (CRE)**

The Reporting System is used to handle all green/red generated during final countdown.

**Closed-Circuit Television Network (CCTV)**

The PPF, HPF and UCIF are equipped with internal closed-circuit TV network for monitoring, security and safety activities. CCTV can be distributed within the CSG facility to any desired location. Hazardous operations such as fuelling are recorded. This system is also used for distribution of launch video transmission.

**Public One-Way Announcement System (SONO)**

The public one-way announcement system ensures emergency announcement, alarms or messages to dedicated CSG locations.

The system is activated through the consol of a Site managers.

### 6.3.4. Transportation and Handling

For all intersite transportation including transportation from the port of arrival of spacecraft and support equipment, CSG provides wide range of the road trailers, trolley and trucks. These means are adapted to various freight categories as standard, hazardous, fragile, oversized loads, low speed drive, etc.

The spacecraft is transported either:

- inside its container on the open road trailer,
- in the dedicated Payload Containers CCU ("Container Charge Utile") mainly between PPF and HPF and UCIF,
- encapsulated inside the Launch Vehicle Upper Composite between UCIF and Launch Pad.

The Payload Containers CCU ensures transportation with low mechanical loads and maintains environments equivalent to those of clean rooms. Two Containers are available:

- CCU2 with maximum capacity 5 tons, internal dimensions Ø3,65 × 10,38 m height;
- CCU3 with maximum capacity 22 tons, internal dimensions 5,20 × 5,20 × 17,10 m;

Handling equipment including travelling cranes and trolleys needed for spacecraft and its support equipment transfers inside the building, are available and their characteristics are described in the EPCU User's Manual. Spacecraft handling equipment is provided by the Customer (refer to para. 4.2.4.3.).

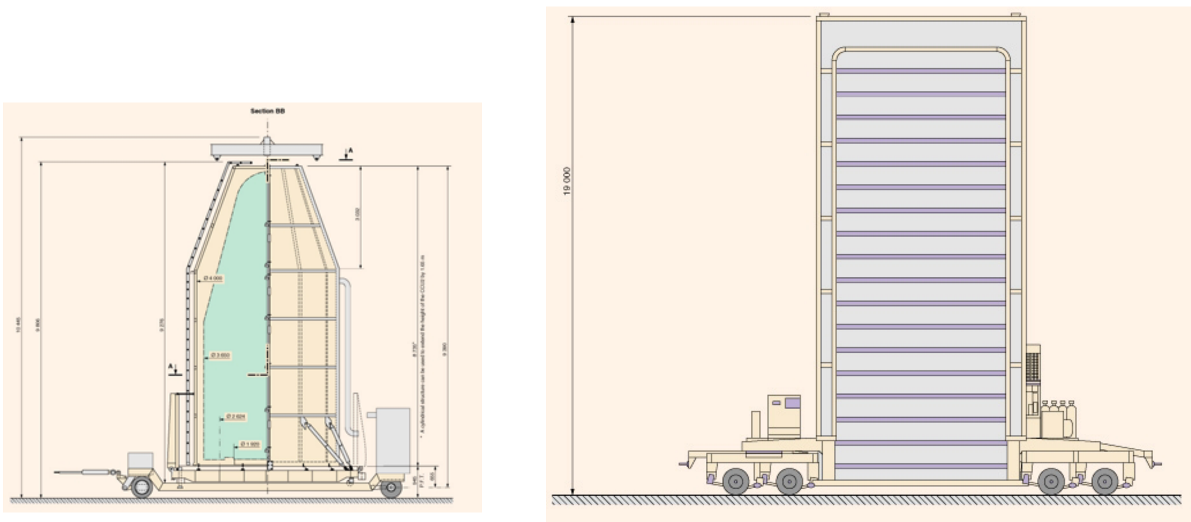



Figure 6.19 – The CCU2 and CCU3 Payload containers

### 6.3.5. Fluids and Gases

Arianespace provides the following standard fluids and gases to support the Customer launch campaign operations:

- industrial quality gases:

- **compressed air** supplied through distribution network,
- **nitrogen** (**$GN_2$**) of grade N50 supplied through distribution network (from tanks) or in 50 l bottles,
- **nitrogen** (**$GN_2$**) of grade N30 supplied through distribution network only in S3 area,
- **helium** (**GHe)** of grade N55, supplied through distribution network from tanks (limited capacity) or in 50 l bottles.

- industrial quality liquids:

- nitrogen (**$LN_2$**) N30 supplied in 35 or 60 l Dewar flasks,
- isopropylic alcohol (**IPA)** "MOS SELECTIPUR";
- demineralized water,

Additionally, breathable-air and distilled-water networks are available in the HPF for hazardous operations.

Any gases and liquids different from the standard fluid delivery (different fluid specification or specific use: $GN_2$-N60, deionized water …) can be procured. The Customer is invited to contact Arianespace for their availability.

The CSG is equipped with laboratories for chemical analysis of fluids and gases. This service shall be requested by the Customer as option.

Arianespace does not supply propellants. Propellant analyses, except Xenon, can be performed on request.

**Disposal of chemical products and propellants are not authorized at CSG and wastes must be brought back by the Customer.**

## 6.4. CSG OPERATIONS POLICY

### 6.4.1. CSG planning constraints

Normal working hours at the CSG are based on 2 Shifts of 8 hours per day, between 6:00 am and 10:00 pm from Monday to Friday.

Work on Saturday can be arranged on a case-by-case basis with advance notice and is subject to negotiations and agreement of CSG Authorities. No activities should be scheduled on Sunday and public holiday. In all cases, access to the facility is possible 24 hours a day, 7 days a week, with the following restrictions, mainly due to safety reasons:

- no hazardous operation or propellant in the vinicity
- no facility configuration change
- use of cranes and other handling equipment only by certified personnel
- no requirement for range support

After spacecraft processing and transfer to other facilities and with advance notice from Arianespace, the PPF may be used by another spacecraft. In this case the spacecraft equipment shall be evacuated from the PPF Clean room 24 hours after spacecraft departure.

The CSG is equipped with different storage facilities that can be used as for the temporary equipment storage during the campaign and, optionally, outside of the campaign.

### 6.4.2. Security

The French Government, CSG Authorities, and Arianespace maintain strict security measures that are compliant with the most rigorous international and national agreements and requirements and they are applicable to the three launch system Ariane, Soyuz and Vega and allow strictly limited access to the spacecraft.

The security management is also compliant with the US DOD requirements for the export of US manufactured satellites or parts, and has been audited by American Authorities (e.g. in frame of ITAR rules).

The security measures include:

- Restricted access to the CSG at the road entrance with each area guarded by the Security service,
- Escort for the satellite transportation to and within the CSG,
- Full control of the access to the satellite: access to the facilities used for spacecraft preparation is limited to authorized personnel only through a dedicated electronic card system; the clean and control rooms are monitored 24 hours a day and 7 days a week by a CCTV system with recording capability.

Security procedures can be adapted to the specific missions according to the Customer's requirements.

### 6.4.3. Safety

The CSG safety division is responsible for the application of the CSG Safety Rules during the campaign and especially for the equipment, operator certification, and permanent operation monitoring.

All CSG facilities are equipped with safety equipment and first aid kits. Standard equipment for various operations like safety belts, gloves, shoes, gas masks, oxygen detection devices, propellant leak detectors, etc. are provided by Arianespace. On request from the Customer, CSG can provide specific items of protection for members of the spacecraft team.

During hazardous operations, a specific safety organization is activated (officers, equipment, fire brigade, etc.).

Any activity involving a potential source of danger is to be reported to CSG, which in return takes all steps necessary to provide and operate adequate collective protection equipment, and to activate the emergency facilities.

The spacecraft design and spacecraft operations compatibility with CSG safety rules is verified according with mission procedure described in the Chapter 7.

### 6.4.4. Training Course

In order to use the CSG facility in a safe way, Arianespace will provide general training courses for Customer team. In addition the training courses for program-specific needs (e.g., safety, propellant team, crane and handling equipment operations and communication means) will be given to appointed operators.

### 6.4.5. Customer assistance

#### 6.4.5.1. Visas and Access Authorization

For entry to French Guyana the Customer will be required to obtain entry visas according to the French rules.

Arianespace may provide support to address special requests to the French administration as needed.

The access badges to the CSG facility will be provided by Arianespace according to the Customer request.

#### 6.4.5.2. Customs Clearance

The satellites and associated equipment are imported into French Guiana on a temporary basis, with exemption of duties. By addressing the equipment to CSG with attention of ARIANESPACE, the customer benefits from the adapted transit procedure (fast customs clearance) and does not have to pay a deposit, in accordance with the terms agreed by the Customs authorities.

However, if, after a campaign, part of the equipment remains in French Guiana, it will be subject to payment of applicable local taxes.

Arianespace will support the Customer in obtaining customs clearances at all ports of entry and exit as required.

#### 6.4.5.3. Personnel Transportation

Customers have access to the public rental companies located at Rochambeau airport or through the assistance of Arianespace's affiliated company Free-Lance. Arianespace provides the transportation from and to Rochambeau Airport, and Kourou, at arrival and departure, as a part of the General Range Support.

#### 6.4.5.4. Medical Care

The CSG is fully equipped to give first medical support on the spot with including first aide kits, infirmary, and ambulance. More over the public hospital with very complete and up to date equipment are available in Kourou and Cayenne.

The Customer team shall take some medical precautions before the launch campaign: the yellow fever vaccination is mandatory for any stay in French Guiana and anti-malaria precautions are recommended for persons supposed to enter the forest areas along the rivers.

#### 6.4.5.5. VIP Accommodation

Arianespace may assign some places for Customer's VIP in the Mission Control Center (Jupiter 2) for witnessing of the final chronology and launch. The details of this VIP accomodation shall be agreed with advance notice.

#### 6.4.5.6. Other assistance

For the team accommodation, flight reservations, banking, off duty & leisure activities the Customer can use the public services in Kourou and Cayenne or can benefit from the support of Arianespace's affiliated company Free-Lance.

# MISSION INTEGRATION AND MANAGEMENT — Chapter 7

## 7.1. Introduction

To provide the Customer with smooth launch preparation and on-time reliable launch, a customer oriented mission integration and management process is implemented.

This process has been perfected through more than 200 commercial missions and complies with the rigorous requirements settled by Arianespace and with the international quality standards ISO 9000 V:2000 specifications.

The mission integration and management process covers:

- **Mission management** and Mission integration schedule
- **LV procurement** and hardware/software adaptation as needed
- **Systems engineering support**
- **Launch campaign management**
- **Safety assurance**
- **Quality assurance**

The mission integration and management process is consolidated through the mission documentation and accessed and verified during formal meetings and reviews.

## 7.2. Mission management

### 7.2.1. Contract organisation

The contractual commitments between the launch service provider and the Customer are defined in the **Launch Services Agreement (LSA)** with its **Statement of Work (SOW),** and its Technical Specification.

Based on the Application to Use Arianespace' launch vehicles (DUA : "Demande d'Utilisation Arianespace") filled out by the Customer, the Statement of work identifies the task and deliveries of the parties, and the Technical Specification identifies the technical interfaces and requirements.

At the LSA signature, an Arianespace Program Director is appointed to be the single point of contact with the Customer in charge of all aspects of the mission including technical and financial matters. The Program Director, through the Arianespace organization handles the company's schedule obligation, establishes the program priority and implements the high-level decisions. At the same time, he has full access to the company's technical staff and industrial suppliers. He is in charge of the information and data exchange, preparation and approval of the documents, organization of the reviews and meetings.

During the launch campaign, the Program Director delegates his technical interface functions to the Mission Director for all activities conducted at the CSG. An operational link is established between the Program Director and the Mission Director.

Besides the meetings and reviews described hereafter, Arianespace will meet the Customer when required to discuss technical, contractual or management items. The following main principles will be applied for these meetings:

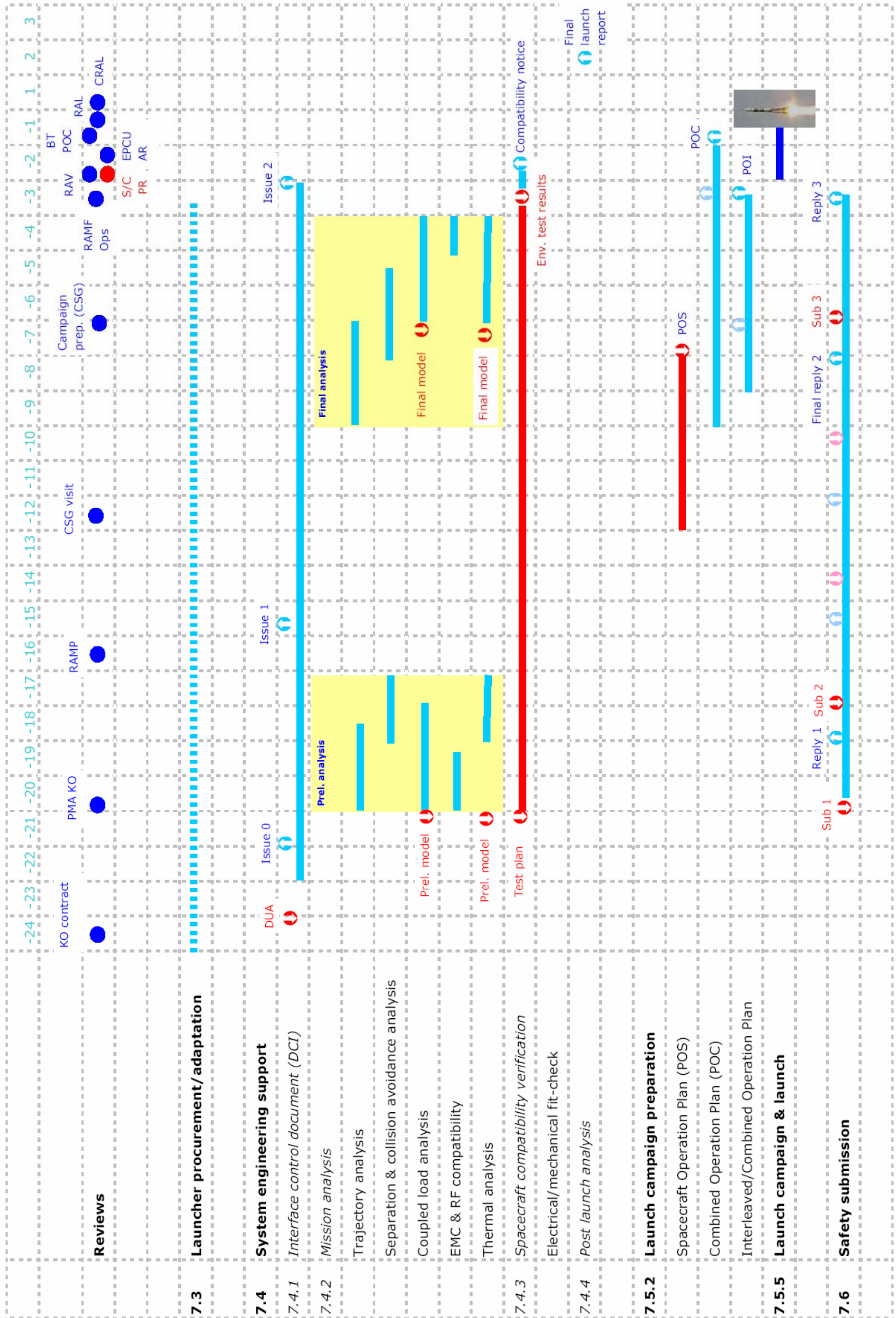
- The dates, location, and agenda will be defined in advance by the respective Program Directors and by mutual agreement;
- The host will be responsible for the meeting organization and access clearance.
- The participation will be open for both side subcontractors and third companies by mutual preliminary agreement

### 7.2.2. Mission integration schedule

The Mission Integration Schedule will be established in compliance with the milestones and launch date specified in the Statement of Work of the Launch Service Agreement. The Mission Schedule reflects the time line of the main tasks described in detail in the following paragraphs.

A typical schedule for non-recurring missions is based on a 24-months timeline as shown in Figure 7.1. This planning can be reduced for recurrent Spacecraft, taken into account the heritage of previous similar flights, or in case of the existence of compatibility agreement between the Spacecraft platform and the launch system.

For a Spacecraft compatible of more than one launch system the time when the launch vehicle (type and configuration) will be assigned to the Spacecraft will be established according to the LSA provisions.




Note: and ■ - the deliverables and tasks of the Customer

Figure 7.1 - Typical Mission Integration Schedule

# 7.3. Launch vehicle procurement and adaptation

## 7.3.1. Procurement/Adaptation process

Arianespace ensures the procurement of LV hardware according to its industrial organization procedures. The following flight items will be available for the Customer launch:

- One equipped launch vehicle and its propellants
- Dedicated flight program (s);
- One standard fairing with optional access doors and optional passive repeaters or radio-transparent windows;
- One adapter or dispenser with its separation system (s), umbilical harnesses, and instrumentation;
- Mission dedicated interface items (connectors, cables and others);
- Mission logo on the LV from Customer artwork supplied not later than 6 months before launch

If any components of the LV need to be adapted (due to specific mission requests, to the output of mission analysis, etc.), adaptation, in terms of specification, definition, and justification, will be implemented in accordance with standard quality rules. The Customer will be involved in this process.

## 7.3.2. LV Flight Readiness Review (RAV "Revue d'Aptitude au Vol")

The review verifies that the launch vehicle, after acceptance tests at the manufacturer's facilities, is technically capable to execute its mission. During this review, all changes, non-conformities, and waivers encountered during production, acceptance tests and storage will be presented and justified. Moreover the L/V-S/C interfaces will be examined with reference to the DCI as well as the status of the launch operational documentation and CSG facility readiness.

The review is conducted by Arianespace and the Customer is invited to attend.


The review will conclude on the authorization to begin the launch campaign or on the reactivation of the L/V preparation if that L/V has already been transported at the CSG or has performed a first part of its integration.

## 7.4. Systems engineering support

The Arianespace's launch service includes the engineering tasks conducted to ensure system compatibility between the Spacecraft, its mission and the launch system, as well as the consistency of their respective interfaces. The final target of this activity is to demonstrate the correct dimensioning of the Spacecraft , the ability of the launch vehicle to perform the mission, to perform the hardware and software customization for the launch and to confirm after the launch the predicted conditions. In this regard, the following activities are included:

- Interface management
- Mission analysis
- Spacecraft compatibility verification
- Post-launch analysis

In some cases, the engineering support can be provided before contract signature to help the Spacecraft platform design process or to verify the compatibility with the launch vehicle.
This activity can be formalised in a Compatibility Agreement for a Spacecraft platform.

### 7.4.1. Interface Management

The technical interface management is based on the Interface Control Document (DCI "Document de Contrôle d'Interface"), which is prepared by Arianespace using inputs from the Technical Specification of the Launch Service Agreement and from the Application to Use Arianespace LV" (DUA) provided by the Customer (the DUA template is presented in Annex 1). This document compiles all agreed Spacecraft mission parameters, outlines the definition of all interfaces between the launch system (LV, operations and ground facilities) and Spacecraft, and illustrates their compatibility.

Nominally, two major updates of the DCI are provided in the course of the mission after the release of the initial version (Issue 0) as a consequence of the LSA signature:

- An update after the preliminary mission analysis (Issue 1);
- An update after the final mission analysis review (Issue 2).

All modifications of the DCI are approved by Arianespace and the Customer before being implemented.

This document is maintained under configuration control until launch. In the event of a contradiction, the document takes precedence over all other technical documents.

## 7.4.2. Mission Analysis

### 7.4.2.1. Introduction

To design the LV mission and to ensure that the mission objectives can be achieved and that the Spacecraft and the launch vehicle are mutually compatible, Arianespace conducts the mission analysis.

Mission analysis is generally organized into two phases, each linked to Spacecraft development milestones and to the availability of Spacecraft input data. These phases are:

- the Preliminary Mission Analysis (PMA); and
- the Final Mission Analysis (FMA).

Depending on Spacecraft and mission requirements and constraints, the Statement of Work fixes the list of provided analysis. Typically, the following decomposition is used:

| Analysis | Preliminary run | Final run |
|---|---|---|
| Trajectory, performance, and injection accuracy analysis | ✓ | ✓ |
| Spacecraft separation and collision avoidance analysis | ✓ | ✓ |
| Dynamic Coupled Loads Analysis (CLA); | ✓ | ✓ |
| Electromagnetic and RF compatibility analysis, | ✓ | ✓ |
| Thermal analysis | if necessary | ✓ |

Note: The Customer can require additional analysis as optional services.

Some of the analysis can be reduced or canceled in case of a recurrent mission.

Mission analysis begins with a kick-off meeting. At the completion of each phase, a Preliminary Mission Analysis Review RAMP ("Revue d'Analyse de Mission Préliminaire") and RAMF ("Revue d'Analyse de Mission Finale"), are held under the joint responsibility of Arianespace and the Customer with support of the appropriate document package.

### 7.4.2.2. Preliminary Mission Analysis

The purposes of the Preliminary Mission Analysis are as follows:

- to describe the compliance between the LV and the Spacecraft;
- to evaluate the environment seen by the Spacecraft to enable the Customer to verify the validity of Spacecraft dimensioning;
- to review the Spacecraft test plan (see chapter 4)
- to identify all open points in terms of mission definition that shall be closed during the Final Mission Analysis
- to identify any deviation from the User's Manual (waivers).

The output of the Preliminary Mission Analysis will be used to define the adaptation of the mission, flight, and ground hardware or to adjust the Spacecraft design or test program as needed. Based on the results of the RAMP, the DCI will be updated, reissued and signed by both parties as Issue 1.

#### *7.4.2.2.1. Preliminary Trajectory, Performance, and Injection Accuracy Analysis*

The preliminary trajectory, performance, and injection accuracy analysis comprises:

- definition of the preliminary reference trajectory and verification of the short and long range safety aspects;
- definition of flight sequences up to separation command and deorbitation of the upper stage if necessary;
- definition of the orbital parameters at separation
- evaluation of nominal performance and the associated margins with regard to Spacecraft mass and propellant reserves and preliminary assessment of launch mass budget;
- evaluation of orbit accuracy;
- verification of compliance with attitude requirements during flight, if any, and evaluation of attitude accuracy at separation;
- the tracking and ground station visibility plan.

#### *7.4.2.2.2. Preliminary Spacecraft separation and collision avoidance analysis*

The preliminary Spacecraft separation and collision avoidance analysis comprises:

- definition of the sequence of events;
- evaluation of the relative velocity between the Spacecraft and the LV and their respective attitude;
- verification of the feasibility of the required orientation
- verification of the post separation kinematic conditions requirements taking into account sloshing effect
- definition of the necessary separation energy
- clearance evaluation during Spacecraft separation;
- short and long term non-collision prospects after Spacecraft separation.

#### 7.4.2.2.3. Preliminary dynamic coupled loads analysis (CLA)

The preliminary CLA uses a preliminary Spacecraft dynamic model provided by the Customer according to the Arianespace specification [TBD].

The preliminary dynamic coupled load analysis CLA:

- performs the modal analysis of the LV and the Spacecraft
- provides the dynamic responses of the Spacecraft for the most severe load cases induced by the LV;
- gives, at nodes selected by the relative Customer, the min-max tables and the time history of forces, accelerations, and deflections as well as L/V –Spacecraft interface acceleration and force time histories.
- provides inputs to analyze, with Arianespace, requests for notching during the Spacecraft qualification tests;

The results of the CLA allow the Customer to verify the validity of Spacecraft dimensioning and to adjust its qualification test plan, if necessary, after discussion with Arianespace.

#### 7.4.2.2.4. Preliminary Electromagnetic and RF Compatibility Analysis

This study allows Arianespace to check the compatibility between the frequencies used by the LV, the range, and the Spacecraft during launch preparation and flight. The analysis is intended to verify that the Spacecraft-generated electromagnetic field is compatible with LV and range susceptibility levels, and vice versa, as defined in Chapter 3 & 4 of this manual.

The Spacecraft frequency plan, provided by the Customer in accordance with the DUA template, is used as input for this analysis.

The results of the analysis allow the Customer to verify the validity of the Spacecraft dimensioning and to adjust its test plan or the emission sequence if necessary.

#### 7.4.2.2.5. Preliminary Thermal Analysis

A preliminary thermal analysis is performed if necessary. This analysis allows to predict the Spacecraft nodes temperatures during ground operations and flight, to identify potential areas of concern and, if necessary, needed adaptations to the mission.

A Spacecraft thermal model provided by the Customer in accordance with Arianespace specifications [TBD] is used as input for this analysis.

### 7.4.2.3. Final Mission Analysis (FMA)

The Final Mission Analysis focuses on the actual flight plan and the final flight prediction. The Final mission demonstrates the mission compliance with all Spacecraft requirement and reviews the Spacecraft test results (see chapter 4) and states on its qualification.

Once the final results have been accepted by the Customer, the mission is considered frozen. The DCI will be updated and reissued as Issue 2.

#### *7.4.2.3.1. Final trajectory, performance, and injection accuracy analysis*

The final trajectory analysis defines:

- The LV performance, taken into account actual LV (mass breakdown, margins with respect to propellant reserves, propulsion parameters adjustments, etc.) and Spacecraft properties.
- The nominal trajectory or set of trajectories (position, velocity and attitude) for confirmed launch dates and flight sequence, and the relevant safety aspects (short and long range);
- Injection orbit accuracy prediction;
- Specific attitude sequence during flight, if any, and Spacecraft attitude and associated accuracy at Spacecraft separation;
- The tracking and ground station visibility plan;

The final analysis data allows the generation of the flight program for the on-board computer.

#### *7.4.2.3.2. Final Spacecraft Separation and Collision Avoidance Analysis*

The final Spacecraft separation and collision avoidance analysis updates and confirms the preliminary analysis for the latest configuration data, and actual Spacecraft parameters :

- Last estimate of Spacecraft and LV properties;
- Last estimate of attitude and angular velocities at separation;
- Actual parameters of the separation device.

#### *7.4.2.3.3. Final dynamic coupled loads analysis*

The final CLA updates the preliminary analysis, taking into account the latest model of the Spacecraft validated by tests. It provides:

- For the most severe load cases : the final estimate of the forces and accelerations at the interfaces between the adapter, the final estimate of forces, accelerations, and deflections at selected Spacecraft nodes;
- The verification that the Spacecraft acceptance test plan and associated notching procedure comply with the final data.

#### *7.4.2.3.4. Final Electromagnetic Compatibility Analysis*

The final electromagnetic compatibility analysis updates the preliminary study, taking into account the final launch configuration and final operational sequences of RF equipment with particular attention on electromagnetic compatibility between Spacecraft in the case of multiple launches.

##### *7.4.2.3.5. Final Thermal Analysis*

The final thermal analysis takes into account the final thermal model provided by the Customer. For ground operations, it provides a time history of the temperature at nodes selected by the Customer in function of the parameters of air ventilation around the Spacecraft. During flight and after fairing jettisoning, it provides a time history of the temperature at critical nodes, taking into account the real attitudes of the LV during the entire launch phase.

The study allows Arianespace to adjust the ventilation parameters during operations with the upper composite and up to the launch in order to satisfy, in so far as the system allows it, the temperature limitations specified for the Spacecraft.

### 7.4.3. Spacecraft Design Compatibility Verification

In close relationship with mission analysis, Arianespace will support the Customer in demonstrating that the Spacecraft design is able to withstand the LV environment. For this purpose, the following reports will be required for review and approval:

- **A Spacecraft environment test plan** correlated with requirements described in Chapter 4. Customer shall describe their approach to qualification and acceptance tests. This plan is intended to outline the Customer's overall test philosophy along with an overview of the system-level environmental testing that will be performed to demonstrate the adequacy of the Spacecraft for ground and flight loads (e.g., static loads, vibration, acoustics, and shock). The test plan shall include test objectives and success criteria, test specimen configuration, general test methods, and a schedule. It shall not include detailed test procedures.
- **A Spacecraft environment test file** comprising theoretical analysis and test results following the system-level structural load and dynamic environment testing. This file should summarize the testing performed to verify the adequacy of the Spacecraft structure for flight and ground loads. For structural systems not verified by test, a structural loads analysis report documenting the analyses performed and resulting margins of safety shall be provided.

After reviewing these documents, Arianespace will edit the Compatibility Notice that will be issued before the RAV.

The conclusion of the mechanical and electrical fit-check (if required) between Spacecraft and launch vehicle will also be presented at the RAV.

Arianespace requests to attend environmental tests for real time discussion of notching profiles and tests correlations.

### 7.4.4. Post-launch analysis

#### 7.4.4.1. Injection Parameters

During the flight, the Spacecraft physical separation confirmation will be provided in real time to the Customer.

Arianespace will give within 1 hour after the last separation, the first formal diagnosis and information sheets to Customer concerning the orbit characteristics and attitude of the Spacecraft just before its separation.

For additional verification of LV performance, Arianespace requires the Customer to provide satellite orbital tracking data on the initial Spacecraft orbit including attitude just after separation if available.

The first flight results based on real time flight assessment will be presented during Post Flight Debriefing next to launch day.

#### 7.4.4.2. Flight Synthesis Report DEL "Document d'Evaluation du Lancement"

Arianespace provides the Customer with a Flight Synthesis Report within 45 days after launch. This report covers all launch vehicle/payload interface aspects, flight event sequences, LV performance, injection orbit and accuracy, separation attitude and rates, records for ground and flight environment, and on-board system status during flight.

# 7.5. Launch campaign

## 7.5.1. Introduction

**The Spacecraft launch campaign** formally begins with the delivery in CSG of the Spacecraft and its associated GSE and concludes with GSE shipment after launch.

Prior to the launch campaign, **the preparation phase** takes place, when all operational documentation is issued and the facilities' compliance with Customer' needs is verified.

The launch campaign divided in three major parts differing by operation responsibilities and facility configuration, as following:

- **Spacecraft autonomous preparation**.

  It is includes the operations from the Spacecraft arrival to the CSG and up to the readiness for integration with LV, and is performed in two steps.

  Phase 1: Spacecraft preparation and checkout;

  Phase 2: Spacecraft hazardous operations

  The operations are managed by the Customer with the support and coordination of Arianespace for what concerned the facilities, supplying items and services. The operations are carried out mainly in the PPF and the HPF of the CSG. The major operational document used is an Interleaved Operation Plan (POI "Plan d'Opérations Imbriquées").

- **Combined operations.** It includes the Spacecraft mating on the launch vehicle, adapter, the transfer to the launch pad, the integration on the launch vehicle, and the verification procedures.

  The operations are managed by Arianespace with direct Customer's support. The operations are carried out mainly in the UCIF of the CSG. The major operational document used is the Combined Operation Plan (POC "Plan d'Opérations Combinées").

- **Launch countdown.** It covers the last launch preparation sequences up to the launch. The operations are carried out at the launch pad using dedicated Arianespace/Customer organization.

The following paragraphs provide the description of the preparation phase, launch campaign organization and associated reviews and meetings, as well as typical launch campaign flow chart.

### 7.5.2. Spacecraft launch campaign preparation phase

During the launch campaign preparation phase, to ensure activity coordination and compatibility with CSG facility, Arianespace issues the following operational documentation based on Application to Use Arianespace's Launch Vehicles and the Spacecraft Operations Plan (POS "Plan des Opérations Satellite"):

- An Interleaved Operation Plan (POI);
- A Combined Operations Plan (POC) ;
- The set of detailed procedures for combined operations;
- A countdown manual.

For the Customer benefit, Arianespace can organize **a CSG visit** for Satellite Operations Plan preparation. It will comprise the visit of the CSG facilities, review of a standard POC Master Schedule as well as a verification of ICD provisions and needs.

The operational documentation and related items are discussed at the dedicated **technical meetings** and status of the activity presented at mission analysis reviews and RAV.

#### 7.5.2.1. Operational documentation

*7.5.2.1.1. Application to Use Arianespace's Launch Vehicles (DUA "Demande d'utilisation Arianespace")*

Besides interfaces details, Spacecraft characteristics…. the DUA presents operational data and launch campaign requirement*. See annex 1.*

*7.5.2.1.2. Spacecraft Operations Plan (POS)*

The Customer has to prepare a Spacecraft Operations Plan (POS "Plan d'Opération Satellite") defining the operations to be executed on the Spacecraft from arrival in French Guiana, including transport, integration, checkout and fueling before assembly on the L/V, and operations on the Launch Pad. The POS defines the scenario for these operations, and specifies the corresponding requirements for their execution.

A typical format for this document is shown in Annex 1.

*7.5.2.1.3. Interleaved Operation Plan (POI)*

Based on the Spacecraft Operations Plan and on the interface definition presented in the DCI, Arianespace will issue an Interleaved Operation Plan (POI "plan d'Opérations Imbriquées") that will outline the range support for all Spacecraft preparations from the time of arrival of Spacecraft and associated GSE equipment in French Guiana until the combined operations.

To facilitate the coordination, one POI is issued per launch campaign, applicable to all passengers of a launch vehicle and approved by each of them.

*7.5.2.1.4. Combined Operation Plan (POC)*

Based on the Spacecraft Operations Plan and on the interface definition presented in the DCI, Arianespace will issue a Combined Operation Plan (POC "Plan d'Opérations Combinées") that will outline all activities involving a Spacecraft and the launch vehicle simultaneously, in particular:

- Combined operations scenario and LV activities interfacing with the Spacecraft;
- Identification of all non reversible and non interruptible Spacecraft and LV activities;
- Identification of all hazardous operations involving the Spacecraft and/or LV activities

- Operational requirements and constraints imposed by each satellite and the launch vehicle
- A reference for each operation to the relevant detailed procedure and associated responsibilities.

The POC is approved at the Combined Operations Readiness Reviews (BT POC "Bilan technique POC").

##### *7.5.2.1.5. Detailed procedures for combined operations*

Two types of combined operations are identified:

- Operations involving each Spacecraft or launch vehicle independently : these procedures are specific for each Authority
- Operations involving Spacecraft / Launch Vehicle interaction managed by common procedures.

The common procedures are prepared by Arianespace and submitted to the Customer's approval.

Arianespace use computer-aided activities management to ensure that the activities associated with on-site processing operations are properly coordinated.

Typically the procedure includes the description of the activities to be performed, the corresponding sequence, the identification of the responsibilities, the required support and the applicable constraints.

##### *7.5.2.1.6. Countdown Manual*

Based on the Satellite Operations Plan, Arianespace establishes a countdown manual that gathers all information relevant to the countdown processing on launch day, including:

- A detailed countdown sequence flow, including all communication exchanges (instruction, readiness status, progress status, parameters, etc.) performed on launch day;
- Go/No-Go criteria;
- The communications network configuration;
- A list of all authorities who will interface with the customer, including launch team members' names and functions; and
- Launch abort sequence.

## 7.5.3. Launch campaign organization

### 7.5.3.1 Satellite launch campaign management

During the operations at CSG, the Customer interfaces with the Mission Director (CM "Chef de Mission"). The Program Director, the Customer's contact in the previous phases, maintains his responsibility for all the non-operational activities.

The range operations manager (DDO) interfaces with the Mission Director. He is in charge of the coordination of all the range activities dedicated to Customer's support :

- support in the payload preparation complex (transport, telecommunications,...)
- weather forecast for hazardous operations
- ground safety of operations and assets
- security and protection on the range
- Launcher down range stations set-up for flight

The launch campaign organization is presented in Figure 7.2.

Positions and responsibilities are briefly described in Table 7.1.

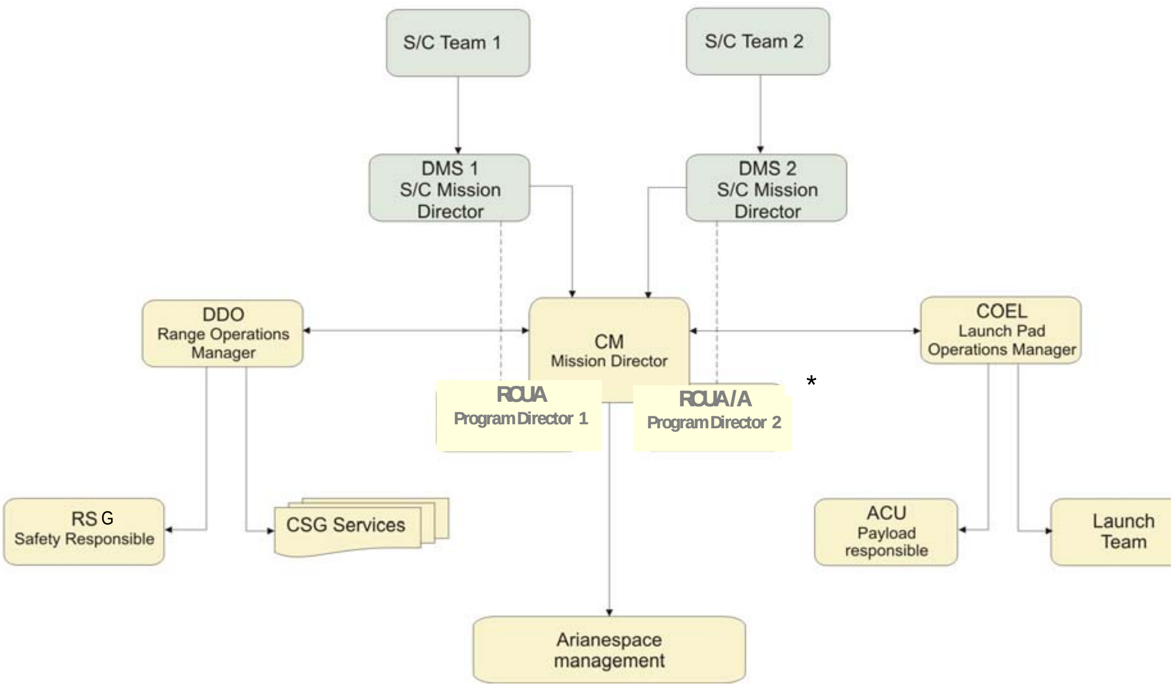
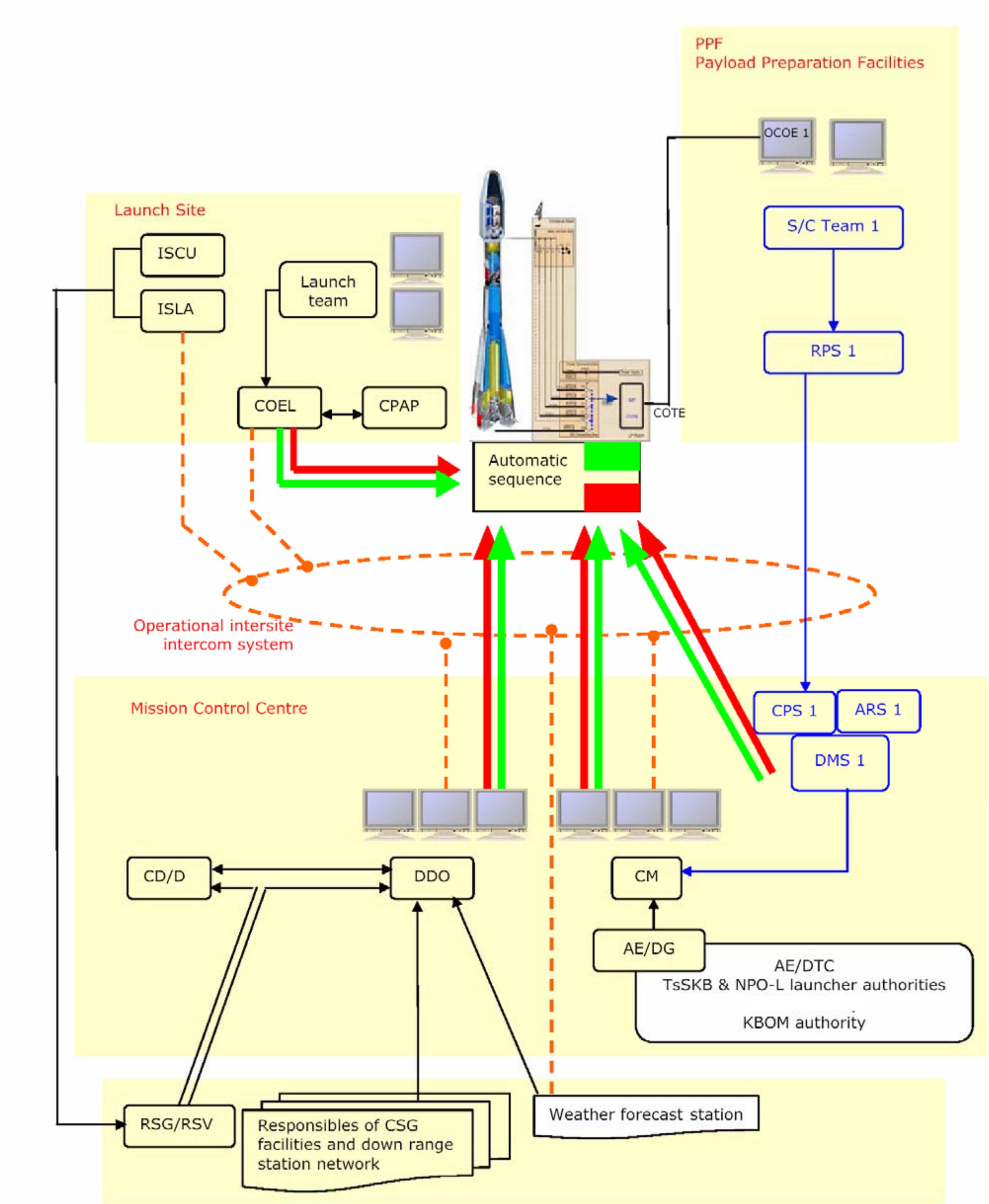



Figure 7.2 – Launch campaign organization (*: in case of dual launch)

Table 7.1 - The post designations and responsibilities

| | | | |
|---|---|---|---|
| **The Customer Representatives** | | | |
| **DMS**<br>Spacecraft Mission Director - *"**D**irecteur de la **M**ission **S**atellite"* | Responsible for Spacecraft preparation to launch and Spacecraft launch campaign.<br>DMS reports S/C and S/C ground network readiness during final countdown.<br>DMS provides confirmation of the Spacecraft acquisition after separation | | |
| **The Spacecraft Manufacturers Representatives** | | | |
| **CPS**<br>Spacecraft Project Manager – *"**C**hef de **P**rojet **S**atellite"* | The CPS managed the S/C preparation team. Usually he is representative of the S/C manufacturer. | **RPS**<br>Spacecraft Preparation Manager – *"**R**esponsable de la **P**réparation **S**atellite"* | Responsible for the preparation, activation, and checkout of the Spacecraft. Provides final S/C status to DMS during countdown. |
| **ARS**<br>Satellite Ground Stations Network Assistant – *"**A**djoint **R**eseau **S**tations sol satellite"* | Responsible of Satellite Orbital Operations Centre. Provides the final Satellite Network readiness to DMS during countdown. | | |
| **The Arianespace representatives** | | | |
| **DG**<br>Chief **O**perating **O**fficer – *"**D**irecteur **G**énéral"*<br><br>*supported by* **DTC** | Ensures the Arianespace's commitments fulfillment-Flight Director during final countdown | **CM**<br>Mission Director – *"**C**hef de **M**ission"* | Responsible for preparation and execution of the launch campaign and final countdown. |
| **COEL**<br>Launch Site Operations Manager – *"**C**hef des **O**pérations **E**nsemble de **L**ancement"* | Responsible for the preparation, activation and checkout of the launch vehicle and associated facilities. Coordinates all operations on the launch pad during final countdown. | **ACU**<br>Payload Deputy - *"**A**djoint **C**harge **U**tile"* | COEL's deputy in charge of all interface operations between S/C and L/V. |
| **CPAP**<br>Arianespace Production Project Manager - *"**C**hef de **P**rojet **A**rianespace **P**roduction"* | Launch vehicle authority: coordinates all technical activities allowing to state the L/V flight readiness | **RCUA**<br>Arianespace Payload Manager - *"**R**esponsable **C**harge **U**tile **A**rianespace"* | Responsible for the contractual aspects of the launch. |
| **DTC**<br>*"Directeur Technique Central"* | Chairman of RAV and RAL | | |
| **The Guiana Space Center (CSG) representatives** | | | |
| **CG/D**<br>Range Director | Ensures the CSG's commitments fulfillment. | **DDO**<br>Range Operations Manager - *"**D**irecteur **D**es **O**pérations"* | Responsible for the preparation, activation and use of the CSG facilities and down-range stations and their readiness during launch campaign and countdown. |
| **RMCU**<br>Payload facilities Manager - *"**R**esponsable des **M**oyens **C**harge **U**tile"* | Responsible for EPCU maintenance and technical support for operations in the EPCU facilities. | **RSG**<br>Ground Safety Responsible - *"**R**esponsable **S**auvegarde **S**ol"* | Responsible for the application of the CSG safety rules during campaign and countdown. |
| **RSV**<br>*Flight Safety Responsible – **R**esponsable **S**auvegarde **V**ol* | Responsible for the applications of the CSG safety rules during flight. | | |
| **ISLA**<br>Launch Area Safety Officer - *"**I**ngénieur **S**auvegarde **L**ancement **A**rianespace"* | Representative of the Safety Responsible on the launch site. | **ISCU**<br>Payload Safety Officer - *"**I**ngénieur **S**auvegarde **C**harge **U**tile"* | Responsible for the monitoring of the payload hazardous operations. |

Figure 7.3 – Countdown organization



### 7.5.4. Launch campaign meetings and reviews

#### 7.5.4.1. Introduction

The launch preparation is carried out in permanent interaction between the Customer and the LV team. The planning of activity, critical points, and needs are discussed at daily briefings giving the Customer access to in-time support and total transparency of the operations. A few more formalized meetings and reviews takes place at major milestones of the operational process.

#### 7.5.4.2. Spacecraft preshipment review

Arianespace wishes to be invited to the preshipment or equivalent review, organized by the customer and held before shipment of the Spacecraft to the CSG

Besides Spacecraft readiness, this review may address the CSG and launch vehicle readiness status that will be presented by Arianespace.

#### 7.5.4.3. Satellite transport meeting

Arianespace will hold a preparation meeting with the customer at the CSG before satellite transportation. The readiness of the facilities at entrance port, and at CSG for satellite arrival, as well as status of formal issues and transportation needs will be verified.

#### 7.5.4.4. EPCU acceptance review

The EPCU Acceptance Review is conducted at the CSG at the beginning of the launch campaign.

It addresses the following main points:

- The readiness of the CSG facilities to support all planned satellite autonomous activities, and particularly, the specific customer requests, communication and data transmission, safety support, and logistics;
- The verification that the facility configuration is compliant with DCI requirements and finalization and approval of the POI and POC;
- The approval of the campaign organization, particularly organizational charts, the presentation of each function, individuals involved and their presence on site, and workday planning;
- The status of the safety submission and open points;
- The approval of the EPCU readiness certificate.

The facility configuration for combined operations could be discussed, if required.

#### 7.5.4.5. Spacecraft consent to fuel meeting

The objective of this meeting is to confirm the readiness of the hazardous facility and Spacecraft for fueling, and of the L/V to proceed with the subsequent operations . Readiness statements are issued at the end of the meeting.

#### 7.5.4.6. Combined operations readiness review (BT POC "Bilan Technique POC")

The objective of this review is to demonstrate the readiness of the Spacecraft, the flight items and the CSG facilities to start the combined operations according to POC. It addresses the following main points:

- POC presentation, organization and responsibility for combined operations;
- The readiness of the Upper composite items (adapter, fairing, upper stage): preparation status, non conformities and waivers overview;
- The readiness of the CSG facilities and information on the LV preparation;
- The readiness of the Spacecraft;
- The mass of the payload in its final launch configuration.

#### 7.5.4.7. Transfer readiness review (TRR)

A Transfer Readiness Review is held before the transportation of the fully integrated Upper composite to the launch pad, usually 5 days before launch. The purpose of the review is to authorize the transfer of the Upper Composite and LV stages to the launch pad and to authorize their integration and final launch preparation.

The review is intended to provide a detailed presentation on the status of the mission. It can serve as a preliminary Launch Readiness Review providing more specific and detailed presentation on the mission aspects. The review covers:

- The mission system aspects, launch date/windows, and mission analysis conclusion;
- A synthesis of the previous launch campaign operations with the Upper Composite and the LV and any non-conformities and waivers encountered;
- the readiness of the launch pad facilities and associated services;
- the status of the launch vehicle stages preparation;
- An overview and organizational description of the launch pad activities;

#### 7.5.4.8. Launch readiness review (LRR or RAL "Revue d'Aptitude au Lancement")

A Launch Readiness Review is held one day before launch and after the launch rehearsal. It authorizes the filling of the LV stages and the pursuit of the final countdown and launch. This review is conducted by Arianespace. The Customer is part of the review board.

The following points are addressed during this review:

- the LV hardware, software, propellants and consumables readiness including status of non-conformities and waivers, results of the dress rehearsal, and quality report;
- the readiness of the Spacecraft, Customer's GSE, voice and data Spacecraft communications network including ground stations and control center;
- the readiness of the range facilities (launch pad, communications and tracking network, weather forecast, EMC status, general support services);
- the countdown operations presentation for nominal and aborted launch, and Go/No Go criteria finalization;
- A review of logistics and public relations activities.

#### 7.5.4.9. Post flight debriefing (CRAL " Compte-rendu Apres de Lancement ")

24 hours after the launch Arianespace draws up a report to the Customer, on post flight analysis covering flight event sequences, evaluation of LV performance, and injection orbit and accuracy parameters.

#### 7.5.4.10. Launch service wash-up meeting

At the end of the campaign Arianespace organizes wash-up meetings. The technical wash-up meeting will address the quality of the services provided from the beginning of the project and up to the launch campaign and launch.

The contractual wash-up is organized to close all contractual items.

## 7.5.5. Summary of a typical launch campaign

### 7.5.5.1. Launch campaign time line and scenario

The Spacecraft campaign duration, from equipment arrival in French Guina until, and including, departure from Guiana, shall not exceed 30 calendar days (27 days before launch and day of launch, and three days after launch).

The Spacecraft shall be available for combined operations 8 working days (TBC) prior to the Launch, at the latest, as it will be agreed in the operational documentation.

A typical Spacecraft operational time schedule is shown in Figure 7.4.

The Spacecraft check-out equipment and specific COTE (Check Out Terminal Equipment) necessary to support the Spacecraft/Launch Vehicle on-pad operations shall be made available to ARIANESPACE, and validated, two days prior to operational use according to the approved operational documentation, at the latest.

All Spacecraft mechanical & electrical support equipment shall be removed from the various EPCU buildings & Launch Pad, packed and made ready for return shipment within three working days after the Launch.

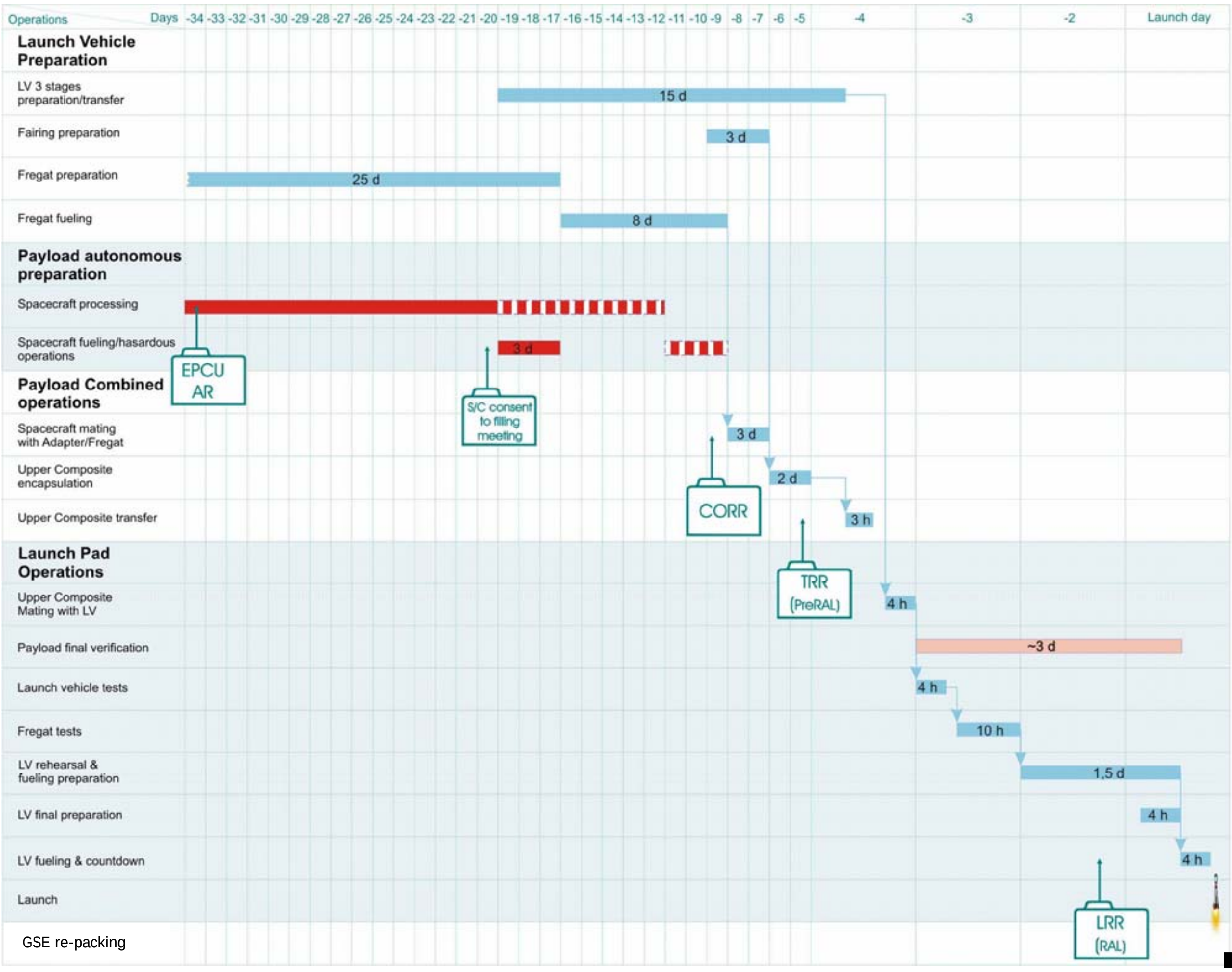



Figure 7.4 - Typical Spacecraft operational time schedule

#### 7.5.5.2. Spacecraft autonomous preparation

*Phase 1 : Spacecraft arrival, preparation and check out*

The Spacecraft and its associated GSE arrive at the CSG through one of the entry ports described in Chapter 6.

Unloading is carried out by the port or airport authorities under the Customers responsibility in coordination with Arianespace. Equipment should be packed on pallets or in containers and protected against rain and condensation.

After formal procedures, the Spacecraft and GSE are transferred by road to CSG's appropriate facilities on the CSG transportation means. On arrival at the PPF the Customer is in charge of equipment unloading and dispatching with CSG and Arianespace support. The ground equipment is unloaded in the transit hall and the Spacecraft, in its container, is unloaded in the high-bay airlock of the PPF. Pyrotechnic systems and any other hazardous systems of the same class are stored in the pyrotechnic devices buildings of the ZSP. Hazardous fluids are stored in a dedicated area.

In the Spacecraft Operations Plan (POS), the Customer defines the way his equipment should be arranged and laid out in the facilities. The Customer states which equipment has to be stored in an air-conditioned environment. Other equipment will be stored under the open shed.

Autonomous operations and checks of the Spacecraft are carried out in the PPF. These activities include:

- Installation of the Spacecraft checkout equipment, connection to the facilities power and operational networks with CSG support;
- Removal of the Spacecraft from containers and deployment in clean rooms. This also applies for flight spare equipment;
- Spacecraft assembly and functional tests (non-hazardous mechanical and electrical tests);
- Verification of the interface with LV, if needed, such as: electrical fit check,...
- Battery charging.

The duration of such activities varies with the nature of the payload and its associated tests.

*Phase 2 : Spacecraft hazardous operations*

Spacecraft filling and hazardous operations are performed in the HPF. The facility and communication network setup are provided by Arianespace.

The pyrotechnic systems are prepared in S2-S4 area including X-ray verification and final assembly by Spacecraft team with Arianespace technical support.

In case of liquid propulsion Arianespace brings the propellant from the storage area to the dedicated facilities of the HPF. The Spacecraft team carries out the installation and validation of Spacecraft GSE, such as pressurization and filling equipment and setup of propellant transfer tanks.

A dedicated meeting authorizes the beginning of filling/hazardous operations.

The Customer fills and pressurizes the Spacecraft tanks to flight level.

Hazardous operations are monitored from a remote control room. CSG Safety department ensures safety during all these procedures.

The integration of hazardous items (category A pyrotechnic devices, etc...) into Spacecraft are carried out in the same way.

Weighing devices are available for Customer in HPF. On request, S/C weighing can be performed under the Customer's responsibility by Arianespace authority.

Spacecraft batteries may be charged in HPF, if needed, except during dynamic hazardous operations.

Fluids and propellant analyses are carried out by Arianespace on Customer's request as described in the DCI.

### 7.5.5.3. Launch vehicle processing

#### *7.5.5.3.1. Preparation of the Lower Three Stages of the Launch Vehicle*

The four strap-on boosters (Soyuz first stage), the central core (second stage), and the Soyuz third stage are assembled, and integrated together in the LV Integration Building (MIK) of the Soyuz Launch Area. Autonomous and combined tests are performed on the first, second, and third Soyuz stages. Then the three stage launch vehicle is transported to the launch pad and erected in vertical position. These activities are conducted in parallel with the Spacecraft activities in PPF/HPF/UCIF.

#### *7.5.5.3.2. Fregat Upper-Stage Preparation*

The Fregat upper stage is installed on its test banch inside LV Integration Building (MIK), where the following operations are performed:

• Fregat autonomous verification;

• Fit check of the adapter/dispenser (mechanical and electrical) with the Fregat.

Then Fregat is transported to the S3B – one of the UCIF clean halls for its fueling, last verifications, and integration with adapter and Spacecraft.

These activities are performed in parallel with Spacecraft preparation and may interact with Spacecraft fueling if the same room is used. The campaign planning will properly arbitrate time-sharing, if needed.

### 7.5.5.4. Combined operations

*7.5.5.4.1. Operations in the UCIF*

The Spacecraft integration with the adapter/dispenser, the Fregat upper stage, and the fairing with its adaptation bay is carried out in the UCIF under Arianespace responsibility. After delivery all these parts to UCIF and their verification and acceptance, the combined operations readiness review (BT-POC) authorizes the combined operations. The combined operations include the following activities:

- Final preparation of the Spacecraft;
- Mating of the Spacecraft onto the adapter/dispenser (Spacecraft stack) and associated verification;
- Integration of the Spacecraft stack on the already filled Fregat and associated verification;
- Constitution of the Upper Composite with encapsulation of the Spacecraft stack in the vertical position;
- Umbilical lines verification.

*7.5.5.4.2. Transfer to launch pad*

After the Transfer Readiness Review, the Upper Composite is transferred by road to the Launch Pad. The duration of this transfer is approximately TBD hours.

### 7.5.5.5. Launch pad operations

*7.5.5.5.1. Launch Pad Preparation Activities*

The setup of Spacecraft COTE and the verification of the launch pad ground segment are performed as early as possible in the campaign. A countdown chronology rehearsal based on the launch countdown procedures is conducted to allow teams to get familiar with nominal and abort procedures.

*7.5.5.5.2. Final integration on the launch pad*

After its arrival on the launch pad, the upper composite is placed on the top of the third stage by the launch pad traveling crane, and mated with the launch vehicle. After mating of the payload on the launch vehicle, the ventilation and electric umbilical are connected to the upper composite.

*7.5.5.5.3. Launch preparation activities*

Launch preparation activity is held usually during 4 days including launch day. The respective procedures, requirements, and constraints are described in the Combined Operations Plan and associated documents.

Typical launch pad activities are described as following:

**Four days before the launch:**

- LV 3-stages transfer from Integration building to the launch pad and erection into the vertical position;
- LV 3-stages connection to the launch pad (umbilical, ventilation, filling pipes, etc.);
- Upper Composite transfer from UCIF to the launch pad;
- Upper Composite mating on the 3-rd stage and umbilical connection; and
- Electrical line verification.

**Three days before the launch:**

- Three-stage LV countdown rehearsal;
- Fregat preparation and verification;
- Activation of LV and Fregat TM systems for full RF compatibility verification;
- Spacecraft autonomous preparation and;
- Upper-composite launch countdown rehearsal.

**Second day before the launch:**

- Other Spacecraft activities if needed.
- LV filling preparation.

**Launch day (countdown chronology):**

- LV preparation for launch;
- LV propellant filling operations; and
- Final launch countdown.

The Upper Composite launch countdown rehearsal implies the activation of major part of the electrical and mechanical on-board and ground sub-systems involved in launch, together with Spacecraft systems and ground network. The major objective of this rehearsal is the verification of the interfaces and the training of the Spacecraft and launch vehicle teams.

*7.5.5.5.4. Launch countdown*

The major countdown activity starts approximately 8 hours before lift-off. During this time, the Customer performs the final Spacecraft preparation and verification. The Spacecraft's final RF flight configuration set up must be completed before -1h30m and remains unchanged until 20 s after separation.

The Customer can require a hold or abort of the countdown up to the -20s before lift-off. It can be done automatically according to established countdown procedures.

Figure 7.5 shows major events in the countdown chronology on launch day.

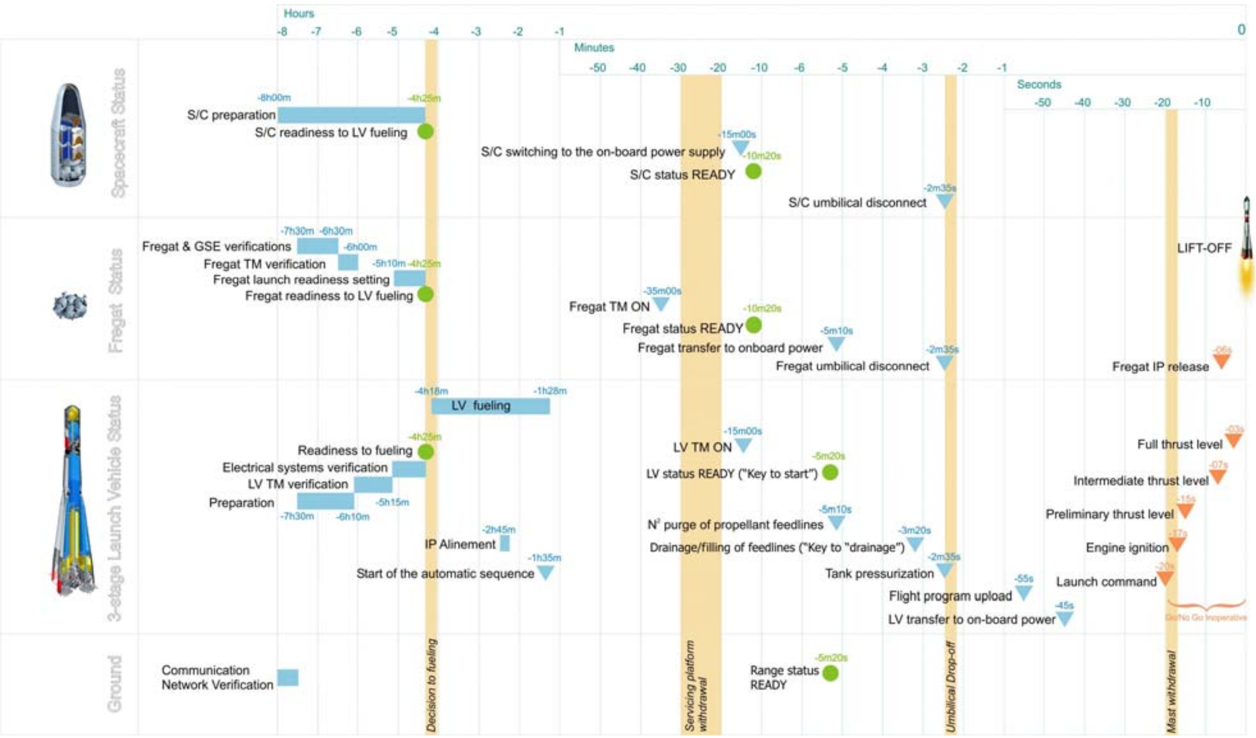



Figure 7.5 - The countdown chronology

*7.5.5.5.5. Launch postponement*

Three different situations must be considered for launch postponement, depending on the decision time:

- Decision before LV fueling (–4h18mm): The new launch date can be scheduled within ten days following LV installation on the pad. Beyond those ten days, the launch vehicle would require additional verification in the LV integration building after demating of the Upper Composite.
- Decision after the beginning of the fueling sequence (after –4h18mm) and before the Launch order(-20s): The new launch date can be rescheduled within 24 hours of the first launch attempt.

  Note: In the event of a launch abort after upper-composite umbilical disconnection (–2m35s), reconnection will occur within 1 hour and 30 minutes (TBC). The last instant lines connecting Spacecraft and COTE remain active.
- Decision after Launch order (-20s): The launcher must be removed from the pad for refurbishment. After the Spacecraft is set into a safe mode and brought back to the EPCU, LV removal operations are executed in the reverse order of the scenario used for setup.

## 7.6. Safety assurance

### 7.6.1.General

The safety objectives are to protect the staff, facility and environment during launch preparation, launch and flight. This is achieved through preventive and palliative actions:

- Short and long range flight safety analysis based on Spacecraft characteristics and on trajectory ground track;
- Safety analysis based on the Spacecraft safety submission;
- Training and prevention of accidents;
- Safety constraints during hazardous operations, and their monitoring and coordination;
- Coordination of the first aide in case of accident.

CSG is responsible for the implementation of the Safety Regulations and for ensuring that these regulations are observed. All launches from the CSG require approvals from Ground and Flight Safety Departments. These approvals cover payload hazardous systems design, all transportation and ground activities that involve Spacecraft and GSE hazardous systems, and the flight plan.

These regulations are described in the document "CSG Safety Regulation" ("Réglement de savegarde du CSG").

### 7.6.2.Safety submission

In order to obtain the safety approval, a Customer has to demonstrate that his equipment and its utilization comply with the provisions of the Safety Regulations. Safety demonstration is accomplished in several steps, through the submission of documents defining and describing hazardous elements and their processing. Submission documents are prepared by the Customer and are sent to Arianespace providing the adequate support in the relation with CSG Authorities.

The time schedule for formal safety submissions shows the requested deadlines, working backwards from launch date L is presented in Table 7.2. A safety checklist is given in the Annex 1 to help for the establishment of the submission documents.

### 7.6.3.Safety training

The general safety training will be provided through video presentations and documents submitted to the Customer before or at the beginning of the launch campaign. At the arrival of the launch team at CSG a specific training will be provided with on-site visits and detailed practical presentations that will be followed by personal certification.

In addition, specific safety training on the hazardous operations, like fueling, will be given to the appointed operators, including operations rehearsals.

Table 7.2 - Safety Submission Time Schedule

| **Safety Submissions** | **Typical Schedule** |
|---|---|
| **Phase 0 – Feasibility (optional)**<br>A Customer willing to launch a satellite containing inventive and innovating systems or subsystems can obtain a safety advice from CSG through the preliminary submission | Before contract signature |
| **Phase 1 - Design**<br>The submission of the Spacecraft and GSE design and description of their hazardous systems. It shall cover component choice, safety and warning devices, fault trees for catastrophic events, and in general all data enabling risk level to be evaluated. | After the contract signature and before PMA kick-off |
| End of Phase 1 submission | Not later than PMA Review or L-12 m |
| **Phase 2 – Integration and Qualification**<br>The submission of the refined hardware definition and respective manufacturing, qualification and acceptance documentation for all the identified hazardous systems of the Spacecraft and GSE.<br>The submission shall include the policy for test and operating all systems classified as hazardous.<br>Preliminary Spacecraft operations procedures should also be provided. | As soon as it becomes available and not later than L - 12 m |
| End of Phase 2 submission | Not later than L - 7 m |
| **Phase 3 – Acceptance tests and hazardous operations**<br>The submission of the final description of operational procedures involving the Spacecraft and GSE hazardous systems as well as the results of their acceptance tests if any. | Before campaign preparation visit or L - 6 m |
| Approval of the Spacecraft compliance with CSG Safety Regulation and approbation of the procedures for autonomous and combined operations. | Before S/C consent to fuel meeting |

Note:

- Shorter submission process, can be implemented in case of recurrent Spacecraft having already demonstrated its compliance with the CSG safety Regulations.

### 7.6.4. Safety measures during hazardous operations

The Spacecraft Authority is responsible for all Spacecraft and associated ground equipment operations.

The CSG safety department representatives monitor and coordinate these operations for all that concerns the safety of the staff and facilities.

Any activity involving a potential source of danger is to be reported to the CSG safety department representative, which in return takes all steps necessary to provide and operate adequate collective protection, and to activate the emergency facilities.

Each member of the Spacecraft team must comply with the safety rules regarding personal protection equipment and personal activity. The CSG safety department representative permanently verifies their validity and he gives the relevant clearance for the any hazardous operations.

On request from the Customer, the CSG can provide specific protection equipment for members of the Spacecraft team.

In case of the launch vehicle, the Spacecraft, and, if applicable its co-passenger imposes crossed safety constraints and limitations, the Arianespace representatives will coordinate the respective combined operations and can restrict the operations or access to the Spacecraft for safety reasons.

## 7.7. Quality assurance

### 7.7.1. Arianespace's quality assurance system

To achieve the highest level of reliability and schedule performance, the Arianespace's Quality Assurance system covers the launch services provided to Customer, and extends up to the launch vehicle hardware development and production by major and second level suppliers, in addition to their proper system imposed by their respective government organization.

Arianespace quality rules and procedures are defined in the company's Quality Manual. This process has been perfected through a long period of implementation, starting with the first ARIANE launches more than 20 years ago, and is certified as compliant with the ISO 9000 : V 2000 standard.

The extension of the commercial operations to Soyuz does not affect the quality assurance system, and the same rules are applied for the new industrial partners.

Soyuz's major subcontractors and suppliers are certified in accordance with government and industry regulations, that comply with the international requirements of the ISO 9001-9002:2000 standard. Their quality system is proven by the number of flights accomplished and by the high level of reliability achieved. It should be noted that the similar quality rules are applied to the three-stage Soyuz as for manned flights to the International Space Station.

The system is based on the following principles and procedures:

**A. Appropriate management system.**

The Arianespace organization presents a well defined decisional and authorization tree including an independent Quality Directorate responsible for establishing and maintaining the quality management tools and systems, and setting methods, training, and evaluation activities (audits). The Quality directorate representatives provide un-interrupted monitoring and control at each phase of mission: hardware production; satellite-LV compliance verification, and launch operations.

**B. Configuration management, traceability, and proper documentation system.**

Arianespace analyses and registers the modifications or evolutions of the system and procedures, not to affect the hardware reliability and/or interfaces compatibility with Spacecraft. The reference documentation and the rigorous management of the modifications are established under the supervision of the quality department.

**C. Quality monitoring of the industrial activities**

In compliment to the supplier's product assurance system, Arianespace manages the production under the following principles: acceptance of supplier's quality plans with respect to Arianespace quality management specification; visibility and surveillance through key event inspection; approbation through hardware acceptance and non-conformity treatment.

Arianespace has access to the industrial anomaly resolution system build by Soyuz manufacturer since the 60's, combining failure review, analysis, and corrective actions for the whole Soyuz family. The anomaly reviews and acceptance of the LV procurement, gathers this experience and Arianespace methodological approach.

During the Launch campaign, at Customer's request, specific meetings may be organized with the Launch Vehicle and Quality authorities, as necessary, to facilitate the understanding of the anomalies or incidents.

The system is permanently under improvement thanks to the Customer's feedback during Launch Services Wash-up meeting at the end of the mission.

### 7.7.2. Customised quality reporting (optional)

In addition and upon request, ARIANESPACE may provide the Customer with a dedicated access right, and additional visibility on the Quality Assurance (QA) system, by the implementation of:

- A **Quality System Presentation** (QSP) included in the agenda of the contractual Kick-off Meeting. This presentation explicitly reviews the Product Assurance provisions defined in the ARIANESPACE Quality Manual,
- A **Quality System Meeting** (QSM), suggested about 10-12 months before the Launch, where the latest LV production Quality Statement is reviewed, with special emphasis on major Quality and Reliability aspects, relevant to Customer's LV or LV batch. It can be accompanied by visits to main contractor facilities,
- A dedicated **Quality Status Review** (QSR), which can be organized about 3-4 months before launch to review the detailed quality log of Customer's Launch Vehicle hardware.

# APPLICATION TO USE ARIANESPACE'S LAUNCH VEHICLE (DUA) Annex 1

The Customer will preferably provide the DUA as an electronic file, according to the Arianespace template.

# REVIEW AND DOCUMENTATION CHECKLIST

# Annex 2

## A2.1. Introduction

The presented annex contents of the typical documentation and meetings checklist that can be used as a base during contract preparation. The delivery date can be modified according to the Customer's mission schedule, availability of the input data and satellite's production planning.

The dates are given in months, relative to contract kick-off meeting or relative to L, where L is the first day of the latest agreed Launch period, Slot, or approved launch day as applicable.

## A2.2. Arianespace issued documentation

| Ref. | Document | Date | CUSTOMER Action ❶ | Remarks |
|---|---|---|---|---|
| 1 | Mission Integration Schedule | Contract kick-off<br>L - 24 | Approval | |
| 2 | Interface Control Document (DCI): | | | |
| | Issue 0 | L –20 | Approval | |
| | Issue 1 | L –13 | Approval | After RAMP |
| | Issue 2 | L –2 | Approval | After RAMF |
| 3 | Preliminary Mission Analysis Documents | L –16 | Review | 2 weeks before RAMP |
| 4 | Final Mission Analysis Documents | L –3.5 | Review | 2 weeks before RAMF |
| 5 | Interleaved Operations Plan (POI) | L –3 | Review | At RAMF |
| 6 | Range Operations Document (DL) | L –3 | For information | |
| 7 | Combined Operations Plan (POC) | L – 7 weeks | Approval | |
| 8 | Countdown sequence | L – 2 weeks | Review | |
| 6 | Safety Statements: | | | |
| | Phase 1 reply | L –17 | Review | At RAMP |
| | Phase 2 reply | 3 months after each submission | Review | |
| | Phase 3 reply | L-2 | Review | |
| 10 | Injection Data | 60 minutes after separation | For information | |
| 11 | Launch Evaluation Report (DEL) | ❶ | For information | |

❶ 1.5 months after Launch, or 1 month after receipt of the orbital tracking report from the Customer, whichever is later.

## A2.3.Customer issued documentation

| Ref. | Document | Date | ARIANESPACE Action | Remarks |
|---|---|---|---|---|
| ***1*** | Application to Use Soyuz | L –24 | Review | At contract kick-off |
| | Safety Submission Phase 1 | L – 20 | Approval | |
| ***2*** | S/C Dynamic model: | | | |
| | Preliminary | L -19 | Review | |
| | Final | L -6 | Review | |
| ***3*** | S/C thermal model: | | | |
| | Preliminary | L -20 | Review | |
| | Final | L -6 | Review | |
| ***6*** | Safety Submission Phase 2 | L – 17 to L - 9 | Approval | |
| | S/C mechanical environmental Test Plan | L -20 | Review | |
| | Updated S/C data for final mission analysis | L - 6 | Review | |
| | S/C Launch operations Plan (POS) | L –7 | Review | |
| | S/C operations procedures applicable at CSG, including Safety Submission Phase 3 | L – 6 | Approval | |
| ***7*** | Environmental Testing: Instrumentation plan, notching plan, test prediction for Sine test & test plan for Acoustic test according to A4-SG-0-P-01 | L – 5 | Approval | |
| | S/C mechanical environment tests results according to A4-SG-0-P-01 | L –2.5 | Review | |
| | S/C final launch window | L-2.5 | Review | |
| ***8*** | Final S/C mass properties | L - 7 days | Approval | After S/C filling |
| ***9*** | Orbital Tracking report (orbit parameters after separation) | 2 weeks after Launch | For information | |

## A2.4.Meetings and reviews

| *Mtg* | *Title* | *Date❶* | *Subjects❷* | *Location❸* |
|---|---|---|---|---|
| ***1*** | Contractual Kick-Off Meeting | L –24 | M-E | C |
| ***2*** | DUA Review | L –22 | M-E-O-S | E |
| ***3*** | Preliminary Mission Analysis Kick-Off | L –20 | M-E-S | X |
| | - First DCI Review and Ed. 0 signature (1 month after) | | | |
| | - Review of Safety Submission Phase 1 | | | |
| ***4*** | DCI Signature | L –18 | M-E-O | E |
| ***5*** | Prelim. Mission Analysis Review [RAMP] | L –16 | M-E-S | E |
| | - DCI Review | | | |
| | - Safety Submission Status | | | |
| ***6*** | Preparation of S/C Operations Plan [POS] | L –12 | M-O-S | K or C |
| | DCI Review | | | |
| ***7*** | Review of S/C Operations Plan [POS] | L –6 | M-O-S | K |
| | Preparation of Interleaved Ops Plan [POI]. Security aspects | | | |
| | DCI Review | | | |
| ***8*** | Final Mission Analysis kick off | L –9 | M-E-S | C |
| | - DCI Review | | | |
| | - Safety Submission Status | | | |
| ***19*** | Final Mission Analysis Review [RAMF] | L –2.5 | M-E | E |
| ***10*** | Campaign Preparation: Final Meeting | L –3 | M-O-S | E |
| ***11*** | LV Flight Readiness Review (RAV) | L –2 | M-E-O-S | E |
| ***12*** | Satellite preshipment Review | L -2 | M-E | C or X |
| ***13*** | Range Configuration Review | ❹ | M-O-S | K |
| ***14*** | Consent to S/C filling meeting | Before filling | M-O-S | K |
| ***15*** | POC Readiness Review | ❺ | M-O-S | K |
| ***16*** | Transfer Readiness Review (Pre-RAL) | L –5 days | | K |
| ***17*** | Launch Readiness Review (RAL) | L –1 day | M-E-O-S | K |
| ***18*** | Launch campaign wash-up | L –1 day | M-O | K |
| ***19*** | Post Flight Debriefing (CRAL) | 1 day after launch | M-E-O | K |

❶ Meeting target dates are given, taking into account the respective commitments of both parties for the delivery of the documentation as described in this Annex parts 2 & 3.

Dates are given in months, relative to L, where L is the first day of the latest agreed Launch period, Slot, or approved launch day as applicable.

| | |
|---|---|
| ❷ | M ⇒ Management ; E ⇒ Engineering ; O ⇒ Operations ; S ⇒ Safety |
| ❸ | E ⇒ Evry ; K ⇒ Kourou ; C ⇒ CUSTOMER HQ ; X ⇒ Contractor Plant |
| ❹ | To be held at Spacecraft Team arrival in Kourou |
| ❺ | To be held the day before the agreed day for starting the POC Operations |

## A1.1. Spacecraft description and mission summary

<table>
<tr><td>Manufactured by</td><td>Model/Bus</td></tr>
<tr><td colspan="2">DESTINATION<br>Telecommunication* Meteorological* Scientific* Others*<br>Direct broadcasting* Remote sensing* Radiolocalisation*</td></tr>
<tr><td>MASS<br>Total mass at launch TBD kg<br>Mass of satellite in target orbit TBD kg</td><td>DIMENSIONS<br>Stowed for launch TBD m<br>Deployed on orbit TBD m</td></tr>
<tr><td>FINAL ORBIT<br>Zp × Za × inclination; ω; RAAN</td><td>LIFETIME<br>TBD years</td></tr>
<tr><td colspan="2">PAYLOAD<br>TBD operational channels of TBD bandwith<br>Traveling wave tube amplifiers: TBD (if used)<br>Transmit Frequency range: TBD W<br>Receive Frequency range. TBD W<br>EIRP: TBD<br><br>ANTENNAS (TM/TC)<br>Antenna direction and location</td></tr>
<tr><td colspan="2">PROPULSION SUB-SYSTEM<br>Brief description: TBD (liquid/solid, number of thrusters..)</td></tr>
<tr><td colspan="2">ELECTRICAL POWER<br>Solar array description (L x W)<br>Beginning of life power TBD W<br>End of life power TBD W<br>Batteries description TBD (type, capacity)</td></tr>
<tr><td colspan="2">ATTITUDE CONTROL<br>Type: TBD<br>STABILIZATION<br>Spin*<br>3 axis*</td></tr>
<tr><td colspan="2">COVERAGE ZONES OF THE SATELLITE TBD (figure)</td></tr>
</table>

Note : * to be selected.

## A1.2. Mission characteristics

### A1.2.1. Orbit description

**Orbit parameters and its dispersions:**

| | Separation orbit | Spacecraft final orbit (if different) |
|---|---|---|
| • Perigee altitude | _____ ±_____ km | _________ km |
| • Apogee altitude | _____ ±_____ km | _________ km |
| • Semi major axis | _____ ±_____ km | _________ km |
| • Eccentricity | | |
| • Inclination | _____ ±_____ deg | ________ deg |
| • Argument of perigee | _____ ±_____ deg | ________ deg |
| • RAAN | _____ ±_____ deg | ________ deg |

**Orbit constraints**

- Any element constrained by the spacecraft (injection time limitation, aerothermal flux, ground station visibility…)

### A1.2.2. Launch window(s) definitions

#### A1.2.2.1. Constraints and relevant margins

Targeted launch period/launch slot

Solar aspect angle, eclipse, ascending node, moon constraints …

#### A1.2.2.2. Targeted window

The targeted launch window shall be computed using the reference time and reference orbit described in the User's Manual if any. The resulting launch window must include the dual launch window, when applicable, as specified in the User's Manual for any launch period. The launch window's data is preferably supplied as an electronic file (MS Excel). Constraints on opening and closing shall be identified and justified.

### A1.2.3. Flight manoeuvres and separation conditions

#### A1.2.3.1. Attitude control during flight and prior to separation

Any particular constraint that the spacecraft faces up to injection in the separation orbit should be indicated (solar aspect angle constraints, spin limitation due to gyro saturation or others).

Any particular constraint that the spacecraft faces after injection, during the Roll and Attitude Control System sequence prior to separation , should be indicated (solar aspect angle constraints or others).

#### A1.2.3.2. Separation conditions

*A1.2.3.2.1. Separation mode and conditions*

Indicate spinning (axial or transverse) or three-axis stabilization (tip-off rates, depointing, etc., including limits).

*A1.2.3.2.2. Separation attitude*

The desired orientation at separation should be specified by the Customer with respect to the inertial perifocal reference frame [U, V, W] related to the orbit at injection time, as defined below:

U = radius vector with its origin at the center of the Earth, and passing through the intended orbit perigee.
V = vector perpendicular to U in the intended orbit plane, having the same direction as the perigee velocity.
W = vector perpendicular to U and V to form a direct trihedron (right-handed system [U, V, W]).

For circular orbits, the [U, V, W] frame is related to the orbit at a reference time (specified by Arianespace in relation with the mission characteristics) with U defined as radius vector with origin at the Earth center and passing through the launcher CoG (and V, W as defined above).

In case of 3-axis stabilized mode, two of the three S/C axes [U, V, W] coordinates should be specified. In case of spin stabilized mode, the S/C spin axes [U, V, W] coordinates should be specified.

Maximum acceptable angular rate and relative velocity at separation shall be indicated.

#### A1.2.3.3. Separation conditions and actual launch time

Need of adjustment of the separation attitude with regard to the actual launch time (relative to the sun position or other) should be indicated.

#### A1.2.3.4. Sequence of events after S/C separation

Describe main maneuvers from separation until final orbit including apogee firing schedule.

## A1.3. Spacecraft description

### A1.3.1. Spacecraft Systems of Axes

The S/C properties should be given in spacecraft axes with the origin of the axes at the separation plane.

Include a sketch showing the spacecraft system of axes, the axes are noted Xs, Ys, Zs and form a right handed set (s for spacecraft).

### A1.3.2. Spacecraft geometry in the flight configuration

A drawing and a reproducible copy of the overall spacecraft geometry in flight configuration is required. It should indicate the exact locations of any equipment requiring access through shroud, lifting points locations and define the lifting device. Detailed dimensional data will be provided for the parts of the S/C closest to the "static envelope" under shroud (antenna reflectors, deployment mechanisms, solar array panels, thermal protections,...). Include the static envelop drawing and adapter interface drawing.

Preferably, a 3D CAD model limited to 30Mo (IGES or STEP extension) shall be supplied.

### A1.3.3. Fundamental modes

Indicate fundamental modes (lateral, longitudinal) of spacecraft hardmounted at interface

### A1.3.4. Mass properties

The data required are for the spacecraft after separation. If the adaptor is supplied by the Customer, add also spacecraft in launch configuration with adapter, and adapter alone just after separation.

#### A1.3.4.1. Range of major/ minor inertia axis ratio

#### A1.3.4.2. Dynamic out of balance (if applicable)

Indicate the maximum dynamic out of balance in degrees.

#### A1.3.4.3. Angular momentum of rotating components

A1.3.4.4. MBI Properties

| Element (i.e. s/c adapter) | Mass (kg) | C of G coordinates (mm) | | | Coefficients of inertia Matrix (kg. $m^2$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $X_G$ | $Y_G$ | $Z_G$ | $I_{xx}$ | $I_{yy}$ | $I_{zz}$ | $I_{xy*}$ | $I_{yz*}$ | $I_{zx*}$ |
| | | | | | | | | | | |
| Tolerance | | | | | Min/Max | Min/Max | Min/Max | Min/Max | Min/Max | Min/Max |

Notes: CoG coordinates are given in S/C axes with their origin at the separation plane.

Inertia matrix is calculated in S/C axes with origin of the axes at the Center of gravity and 1 g conditions.

The cross inertia terms (*) must be intended as the opposite of the inertia products (Ixy = -Pxy).

### A1.3.5. Propellant / pressurant characteristics

| Tanks | | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|
| Propellant | | | NTO | MMH | NTO | MMH |
| Density | | (kg/m$^3$) | | | | |
| Tank volume | | (l) | | | | |
| Fill factor | | (%) | | | | |
| Liquid volume | | (l) | | | | |
| Liquid mass | | (kg) | | | | |
| Center of gravity of propellant loaded tank | | Xs | | | | |
| | | Ys | | | | |
| | | Zs | | | | |
| Slosh model under 0 g | Pendulum mass | (kg) | | | | |
| | Pendulum length | (m) | | | | |
| | Pendulum attachment point | Xs | | | | |
| | | Ys | | | | |
| | | Zs | | | | |
| | Fixed mass (if any) | | | | | |
| | Fixed mass attachment point (if any) | Xs | | | | |
| | | Ys | | | | |
| | | Zs | | | | |
| | Natural frequency of fundamental sloshing mode (Hz) | | | | | |
| Slosh model under 1 g | Pendulum mass | (kg) | | | | |
| | Pendulum length | (m) | | | | |
| | Pendulum attachment point | Xs | | | | |
| | | Ys | | | | |
| | | Zs | | | | |
| | Fixed mass (if any) | | | | | |
| | Fixed mass attachment point (if any) | Xs | | | | |
| | | Ys | | | | |
| | | Zs | | | | |
| | Natural frequency of fundamental sloshing mode (Hz) | | | | | |

| | | | Pressurant helium | | | |
|---|---|---|---|---|---|---|
| Tanks | | | 1 | 2 | 3 | … |
| Volume | (l) | | | | | |
| Loaded mass | (kg) | | | | | |
| Center of gravity (mm) | | Xs | | | | |
| | | Ys | | | | |
| | | Zs | | | | |

Indicate:

Mass of total pressurant gas: TBD kg

Number of pressurant tanks: TBD

### A1.3.6. Mechanical Interfaces

#### A1.3.6.1. Customer using Arianespace standard adapters

##### *A1.3.6.1.1. Interface geometry*

Provide a drawing with detailed dimensions and nominal tolerances showing:

- the spacecraft interface ring
- the area allocated for spring actuators and pushers
- umbilical connector locations and supports
- the area allocated for separation sensors (if any)
- equipment in close proximity to the separation clampband (superinsulation, plume shields, thrusters)

##### *A1.3.6.1.2. Interface material description*

For each spacecraft mating surface in contact with the launcher adapter and the clampband, indicate material, roughness, flatness, surface coating, rigidity (frame only), inertia and surface (frame only), and grounding.

#### A1.3.6.2. Customer providing its own adapter

Define adaptor and its interface with the launch vehicle according to Arianespace's specifications.

Define the characteristics of the separation system including:

- separation spring locations, type, diameter, free length, compressed length, spring constraint, energy
- tolerances on the above
- dispersion on spring energy vectors
- dispersion of separation system
- clampband tension
- dispersion on pyro device actuation times
- the energy of separation and the energy released in the umbilical connectors

#### A1.3.6.3. Spacecraft accessibility requirements after encapsulation

Indicate items on the spacecraft to which access is required after encapsulation, and give their exact locations in spacecraft coordinates.

### A1.3.7. Electrical interfaces

Provide the following:

- a spacecraft to EGSE links description and diagram as well as a definition of umbilical connectors and links (indicate voltage and current during launch preparation as well as at plug extraction)

  The umbilical links at launch preparation:

| S/C connector pin allocation number | Function | Max voltage (V) | Max current (mA) | Max voltage drop ($\Delta$V) | or | Expected one way resistance ($\Omega$) |
|---|---|---|---|---|---|---|
| 1<br>2<br>3<br>… | | | | | | |

  The umbilical links at umbilical connector extraction (lift-off):

| Function | Max voltage (V) | Max current (mA) |
|---|---|---|
| | | |

- a block diagram showing line functions on the spacecraft side and the EGSE side
- data link requirements on ground (baseband and data network) between spacecraft and EGSE
- a description of additional links used after spacecraft mating on the L/V for the test or ground operation
- the location of the spacecraft ground potential reference on the spacecraft interface frame
- electrical link requirements (data, power, etc.) during flight between the L/V and spacecraft

## A1.3.8. Radioelectrical interfaces

### A1.3.8.1. Radio link requirements for ground operations

Provide the radio link requirements and descriptions between spacecraft, launch site, spacecraft check-out system and PPF and HPF (including re-rad).

Include transmit and receive points location of antenna(e) to be considered for radio links during launch preparation, as well as antenna(e) pattern.

### A1.3.8.2. Spacecraft transmit and receive systems

Provide a description of spacecraft payload telecommunications systems (for information only)

Provide a description of spacecraft telemetry and telecommand housekeeping systems.

For each TM and TC system used on the ground and during launch, give the following:

| Source unit description | | S1 | S2 | S… |
|---|---|---|---|---|
| Function | | | | |
| Band | | | | |
| Carrier Frequency, $F_0$ (MHz) | | | | |
| Bandwidth centered | -3 dB | | | |
| Around $F_0$ | -60 dB | | | |
| Carrier | Type | | | |
| Modulation | Index | | | |
| Carrier Polarization | | | | |
| Local Oscillator Frequencies | | | | |
| 1st intermediate Frequency | | | | |
| 2nd intermediate Frequency | | | | |
| EIRP, transmit (dBm) | Max | | | |
| | Nom | | | |
| | Min | | | |
| Field strength at antenna, receive (dBμ V/M) | Max | | | |
| | Nom | | | |
| | Min | | | |
| Antenna | Type<br>Location<br>Gain<br>Pattern | | | |

The spacecraft transmission plan shall also be supplied as shown in table below.

| Source | Function | During preparation on launch pad | After fairing jettisoning until 20s after separation | In transfer orbit | On station |
|---|---|---|---|---|---|
| S1 | | | | | |
| S2 | | | | | |
| S… | | | | | |

Provide the spacecraft emission spectrum.

#### A1.3.8.3. Spacecraft ground station network

For each satellite ground station to be used for spacecraft acquisition after separation (nominal and back-up stations) indicate the geographical location (latitude, longitude, and altitude) and the radio-electrical horizon for TM and telecommand and associated spacecraft visibility requirements.

### A1.3.9. Environmental characteristics

Provide the following:

- thermal and humidity requirements (including limits) of environment during launch preparation and flight phase
- dissipated power under the fairing during ground operations and flight phase
- maximum ascent depressurization rate and differential pressure
- contamination constraints; and contamination sensible surfaces
- purging requirements (if any)

Indicate the following:

- specific EMC concerns (e.g. lightning, RF protection)
- spacecraft electrical field susceptibility levels
- spacecraft sensitivity to magnetic fields (if any)

## A1.4. Operational requirements

### A1.4.1. Provisional range operations schedule

Provide a main operations list and description (including launch pad activities) and estimated timing (with hazardous operation identification).

### A1.4.2. Facility requirements

For each facility used for spacecraft preparation PPF, HPF, Launch pad provide:

- main operations list and description
- space needed for spacecraft , GSE and Customer offices
- environmental requirements (Temperature, relative humidity, cleanliness)
- power requirements (Voltage, Amps, # phases, frequency, category)
- RF and hardline requirements
- support equipment requirements
- GSE and hazardous items storage requirements

### A1.4.3. Communication needs

For each facility used for spacecraft preparation (PPF, HPF, Launch pad) provide need in telephone, facsimile, data lines, time code ...

### A1.4.4. Handling, dispatching and transportation needs

Provide

- estimated packing list (including heavy, large and non-standard container characteristics) with indication of designation, number, size (L x W x H in m) and mass (kg)
- propellant transportation plan (including associated paperworks)
- a definition of the spacecraft container and associated handling device (constraints)
- a definition of the spacecraft lifting device including the definition of ACU interface (if provided by the Customer)
- a definition of spacecraft GSE (dimensions and interfaces required)
- dispatching list

### A1.4.5. Fluids and propellants needs

#### A1.4.5.1. List of fluids

Indicate type, quality, quantity and location for use of fluids to be supplied by Arianespace.

#### A1.4.5.2. Chemical and physical analysis to be performed on the range

Indicate for each analysis: type and specification.

#### A1.4.5.3. Safety garments needed for propellants loading

Indicate number.

### A1.4.6. Technical support requirements

Indicate need for workshop, instrument calibration.

### A1.4.7. Security requirements

Provide specific security requirements (access restriction, protected rooms, supervision, …)

## A1.5. Miscellaneous

Provide any other specific requirements requested for the mission.

## A1.6. Contents of the spacecraft development plan

The Customer prepares a file containing all the documents necessary to assess the spacecraft development plan with regard to the compatibility with the launch vehicle.

It, at least, shall include:

- spacecraft test plan: define the qualification policy, vibrations, acoustics, shocks, protoflight or qualification model
- requirements for test equipment (adapters, clamp-band volume simulator, etc.)
- tests on the Customer's premises
- test at the range

## A1.7. Definitions, acronyms, symbols

Provide a list of acronyms and symbols with their definition.

## A1.8. Contents of Safety Submission Phases 1 and 2

The Customer prepares a file containing all the documents necessary to inform CSG of his plans with respect to hazardous systems. This file contains a description of the hazardous systems. It responds to all questions on the hazardous items check list given in the document CSG Safety Regulations, and summarized here below.

| Sheet number | Title |
|---|---|
| O | Documentation |
| GC | General comments Miscellaneous |
| A1 | Solid propellant rocket motor |
| A2 | Igniter assembly S & A device. Initiation command and control circuits |
| A3 | GSE operations |
| B1 | Electro-explosive devices ordnance |
| B2 | Initiation command and control circuits |
| B3 | GSE ground tests operations |
| C1 | Monopropellant propulsion system |
| C2 | Command and control circuits |
| C3 | GSE operations |
| AC1 | Dual propellant / propulsion system propellants |
| AC2 | Command and control circuits |
| AC3 | GSE operations |
| D1A | Non ionizing RF systems |
| D2A | Optical systems |
| D3A | Other RF sources laser systems |
| D1B | Electrical systems batteries heaters |
| D2B | Umbilical electrical interfaces |
| D3B | GSE battery operations |
| D1C | Pressurized systems with fluids and gas other than propellants cryogenics |
| D2C | Command and control circuits |
| D3C | GSE operations |
| D1D | Mechanical / electro-mechanical systems<br>Transport / handling devices structure |
| D2D | Other systems and equipment |
| D1E | Ionizing systems / flight sources |
| D2E | Ionizing systems / ground sources |

## A1.9. Contents of Spacecraft Operations Plan (POS)

The Customer defines the operations to be executed on the spacecraft from arrival at the CSG, at the launch site, and up to the launch.

A typical content is presented here below.

1. General

1.1 Introduction

1.2 Applicable documents

2. Management

2.1 Time schedule with technical constraints

3. Personnel

3.1 Organizational chart for spacecraft operation team in campaign

3.2 Spacecraft organizational chart for countdown

4. Operations

4.1 Handling and transport requirements for spacecraft and ancillary equipment

4.2 Tasks for launch operations (including description of required access after encapsulation)

5. Equipment associated with the spacecraft

5.1 Brief description of equipment for launch operations

5.2 Description of hazardous equipment (with diagrams)

5.3 Description of special equipment (PPF, HPF, Launch table)

6. Installations

6.1 Surface areas

6.2 Environmental requirements

6.3 Communications

7. Logistics

7.1 Transport facilities

7.2 Packing list

# ITEMS AND SERVICES FOR AN ARIANESPACE LAUNCH Annex 3

Within the framework of the Launch Service Agreement Arianespace supplies standard items and conduct standard services.

In addition, Arianespace proposes a tailored service, the General Range Service (GRS), to suit the needs of satellite operations during the launch campaign at CSG.

Other items and services, to cover specific Customer's requirements, are additionally provided as options through the Launch Service Agreement or ordered separately.

## A3.1. Mission management

Arianespace will provide a dedicated mission organisation and resources to fulfill its contractual obligations in order to satisfy the Customer's requirements, focusing on the success of the mission: contract amendments, payments, planning, configuration control, documentation, reviews, meetings, and so on ... as described in the chapter 7.

## A3.2. System engineering support

### A3.2.1. Interface management

DCI issue, update and configuration control.

### A3.2.2. Mission analysis

Arianespace will perform the Mission Analyses as defined in chapter 7 in number and nature.

### A3.2.3. Spacecraft Compatibility Verification

Reviewing and approbation of the spacecraft compatibility with the L/V through the documentation provided by the Customer (test results, qualification files...).

### A3.2.4. Post-launch analysis

Injection parameters (S/C orbit and attitude data)

Flight synthesis report (DEL)

## A3.3. Launch vehicle procurement and adaptation

Arianespace will supply the hardware and software to carry out the mission, complying with the launch specification and the Interface Control Document (DCI):

- one equipped 3 stages Soyuz launch vehicle with one dedicated flight program
- one equipped Fregat upper stage with one dedicated flight program
- launch vehicle propellants
- one payload compartment under the fairing, on or inside a dual launch carrying structure*
- one mission logo installed on the fairing and based on the Customer artwork supplied at L-6
- one adapter/dispenser with separation system, umbilical interface connector, umbilical harnesses, and instrumentation
- two Check-Out Terminal Equipment (COTE) racks compatible with the launch pad installation

* access door(s) and passive repeater or RF window are available as options

## A3.4. Launch operations

Arianespace shall provide:

- all needed launch vehicle autonomous preparation (integration, verification and installation …)
- launch vehicle/spacecraft combined operations
- launch pad operations including countdown and launch
- flight monitoring, tracking and reporting

## A3.5. Safety assurance

As defined in chapter 7.

## A3.6. Quality assurance

As defined in chapter 7.

## A3.7. General Range Support (GRS)

The General Range Support provides the Customer, on a lump sum basis, with a number of standard services and standard quantities of fluids (see list hereafter). Request(s) for additional services and/or supply of additional items exceeding the scope of the GRS can be accommodated, subject to negotiation between Arianespace and the Customer.

### A3.7.1. Transport Services

#### A3.7.1.1. Personnel transportation

Transport from and to Rochambeau Airport and Kourou at arrival and departure, as necessary.

#### A3.7.1.2. Spacecraft and GSE transport between airport or harbor and PPF

Subject to advanced notice and performed nominally within normal CSG working hours. Availability outside normal working hours, Saturdays, Sundays and public holidays is subject to advance notice, negociations and agreement with local authorities.

It includes:

- coordination of loading / unloading activities
- transportation from Rochambeau airport and/or Degrad-des-Cannes harbor to CSG and return to airport / harbor of spacecraft and associated equipment of various freight categories (standard, hazardous, fragile, oversized loads, low speed drive, etc...) compliant with transportation rules and schedule for oversized loads. The freight is limited to 12 x 10 ft pallets (or equivalent) in 2 batches (plane or vessel).
- depalletisation of spacecraft support equipment on arrival to CSG, and dispatching to the various working areas
- palletisation of spacecraft support equipment prior to departure from CSG to airport/harbor
- all formality associated with the delivery of freight by the carrier at airport/harbor
- CSG support for the installation and removal of the spacecraft check-out equipment

It does not include:

- the "octroi de mer" tax on equipment permanently imported to Guiana, if any
- insurance for spacecraft and its associated equipment

#### A3.7.1.3. Logistics support

Support for shipment and customs procedures for the spacecraft and its associated equipment and for personal luggage and equipment transported as accompanied luggage.

#### A3.7.1.4. Spacecraft and GSE Inter-Site Transportation

All spacecraft transportation either inside the S/C container or in the payload container (CCU), and spacecraft GSE transportation between CSG facilities.

## A3.7.2. Payload preparation facilities allocation

The Payload Preparation Complex, with its personnel for support and equipped as described in the EPCU User's Manual, may be used simultaneously by several Customers.

Specific facilities are dedicated to the Customer on the following basis: activities performed nominally within normal CSG working hours, or subject to negociations and agreement of authorities, as defined in chapter 6.4 "CSG operations policy".

**PPF and HPF areas**

- spacecraft preparation (clean room) 350 $m^2$
- lab for check-out stations (LBC) 110 $m^2$
- offices and meeting rooms 250 $m^2$
- filling hall dedicated

**Storage**

Any storage of equipment during the campaign.

Two additional months for propellant storage.

**Schedule restrictions**

The launch campaign duration is limited to 30 calendar days, from S/C arrival in French Guiana, to actual departure of the last spacecraft ground support equipment as described in chapter 6. Extension possible, subject to negotiations.

Transfer of S/C and its associated equipment to the HPF facilities not earlier than 21 working days (TBC) before Launch.

Spacecraft Ground Support Equipment must be ready to leave the range within 3 working days after the launch.

After S/C transfer to HPF, and upon request by Arianespace, the spacecraft preparation clean room may be used by another spacecraft.

### A3.7.3. Communication Links

The following communication services between the different spacecraft preparation facilities will be provided for the duration of a standard campaign (including technical assistance for connection, validation and permanent monitoring).

| **Service** | **Type** | **Remarks** |
|---|---|---|
| **RF- Link** | S/C/Ku band | 1 TM / 1 TC through optical fiber |
| **Baseband Link** | S/C/Ku band | 2 TM / 2 TC through optical fiber |
| **Data Link** | V11 and V24 network | For COTE monitoring & remote control |
| **Ethernet** | Planet network, 10 Mbits/sec | 3 VLAN available per project |
| **Umbilical Link** | Copper lines | 2x37 pins for S/C umbilical & 2x37 pins for auxiliary equipment. |
| **Internet** | | Connection to local provider |
| **Closed Circuit TV** | | As necessary |
| **Intercom System** | | As necessary |
| **Paging System** | | 5 beepers per Project |
| **CSG Telephone** | | As necessary |
| **Cellular phone** | GSM | Rental by Customer |
| **International Telephone Links ➊** | With Access Code | ≤ 10 |
| **ISDN (RNIS) links** | Subscribed by Customer | Routed to dedicated Customer's working zone |
| **Facsimile in offices ➊** | | 1 |
| **Video Conference ➊** | Equipment shared with other Customers | As necessary |

Note: ➊ traffic to be paid, at cost, on CSG invoice after the campaign

### A3.7.4. Cleanliness monitoring

Continuous monitoring of organic deposit in clean room, with one report per week.

Continuous counting of particles in clean room, with one report per week.

### A3.7.5. Fluid and Gases Deliveries

| Gases | Type | Quantity |
|---|---|---|
| **Compressed air** | Industrial, dedicated local network | As necessary |
| **GN2** | N50, dedicated local network | As necessary available at 190 bar |
| **GN2** | N30, dedicated network in S3 area | As necessary available at 190 bar |
| **Ghe** | N55, dedicated local network | As necessary, available at 180 or 350 bar |

| Fluid | Type | Quantity |
|---|---|---|
| **LN2** | N30 | As necessary |
| **IPA** | MOS-SELECTIPUR | As necessary |
| **Water** | Demineralised | As necessary |

Note: Any requirement different from the standard fluid delivery (different fluid specification or specific use) is subject to negotiation.

### A3.7.6. Safety

| Equipment | Type | Quantity |
|---|---|---|
| **Safety equipment for hazardous operations**<br>(safety belts, gloves, shoes, gas masks, oxygen detection devices, propellant leak detectors, etc.) | Standard | As necessary |

### A3.7.7. Miscellaneous

One video tape with launch coverage (NTSC, PAL or SECAM) will be provided after the launch.

Office equipment:

- no-break power: 10 UPS 1.4 kVA at S1 or S5 offices for Customer PCs
- copy machines: 2 in S1 or S5 Area (1 for secretarial duties, 1 for extensive reproduction); paper provided

## A3.8. Optional items and services

The following Optional items and Services list is an abstract of the "Tailored and optional services list" available for the Customer and which is updated on a yearly basis.

### A3.8.1. Launch vehicle hardware

- pyrotechnic command
- electrical command
- dry loop command
- spacecraft $GN_2$ flushing
- RF transmission through the payload compartment (either SRP or RF window)
- access doors: at authorized locations, for access to the encapsulated spacecraft

### A3.8.2. Mission analysis

Any additional Mission Analysis study or additional Flight Program requested or due to any change induced by the Customer.

### A3.8.3. Interface tests

Note : any loan or purchase of equipment (adaptor, clampband, bolts, separation pyro set) can be envisaged and is subject to previous test plan acceptance by Arianespace.

- fit-check (mechanical/electrical) with ground test hardware at Customer's premises
- fit-check (mechanical/electrical) with flight hardware in Kourou
- fit-check (mechanical/electrical) with ground test hardware and one shock test at Customer's premises

### A3.8.4. Range Operations

- spacecraft and/or GSE transport to Kourou: the Customer may contact Arianespace to discuss the possibility to use an Arianespace ship to transport the spacecraft and/or its associated equipment and propellant
- additional shipment of S/C support equipment from Cayenne to CSG and return
- extra working shift
- campaign extension above contractual duration
- access to offices and LBC outside working hours without AE/CSG support during the campaign duration
- chemical analysis (gas, fluids and propellants except Xenon)
- S/C weighing
- bilingual secretary
- technical photos
- film processing
- transmission of TV launch coverage to Paris
- transmission of TV launch coverage to the point of reception requested by the Customer
- internet video corner during the spacecraft campaign
- on board camera

# STANDARD PAYLOAD ADAPTERS Annex 4

## A4.1. Adapter 937-SF

The adapter 937-SF was developed by EADS CASA within the framework of the Mars Express launch services program and is qualified for ground and flight operations on the Soyuz LV. It is a composite structure in the form of a truncated cone with a diameter of 937 mm at the level of the spacecraft separation plane (see Figure TBD). The upper ring that interfaces with the spacecraft and the eight lower brackets which interface with the Fregat are made of aluminum alloys, whereas the conical part is a classical sandwich with CFRP skins and an aluminum-honeycomb core.

The adapter 937-SF is equipped with a CASA 937B separation system (a standard Ariane device). The release shock spectrum at the spacecraft/adapter interface is indicated in Figure TBD.

The spacecraft is separated from the launch vehicle by 4 to 8 spring actuators that are also part of the adapter and that bear on the spacecraft rear frame (see Figure TBD). In this way, the relative velocity between the spacecraft and the launch vehicle can be adjusted to mission requirements. Each actuator applies a force up to 1200 N on the spacecraft rear frame with a ± 24 N tolerance. Note that the clamp band tension does not exceed 27,700 N at any time, including dispersions due to temperature variations on ground and in flight. This ensures no gapping or sliding between the spacecraft and adapter interfacing frames during all phases of the mission.

The angular positioning of the spacecraft with respect to the adapter is ensured by the alignment of engraved marks on the interfacing frames at a specified location to be agreed with the user.

The adapter 937-SF is equipped with a set of sensors that are designed to monitor the spacecraft environment.

The adapter 937-SF also holds the electrical harness that is necessary for umbilical links as well as for separation orders and telemetry data transmission. This harness will be tailored to user needs, with its design depending on the required links between the spacecraft and the launch vehicle (see Section TBD).

TO BE ISSUED LATER

Figure A4 1-1 Adapter 937 SF – Load capability

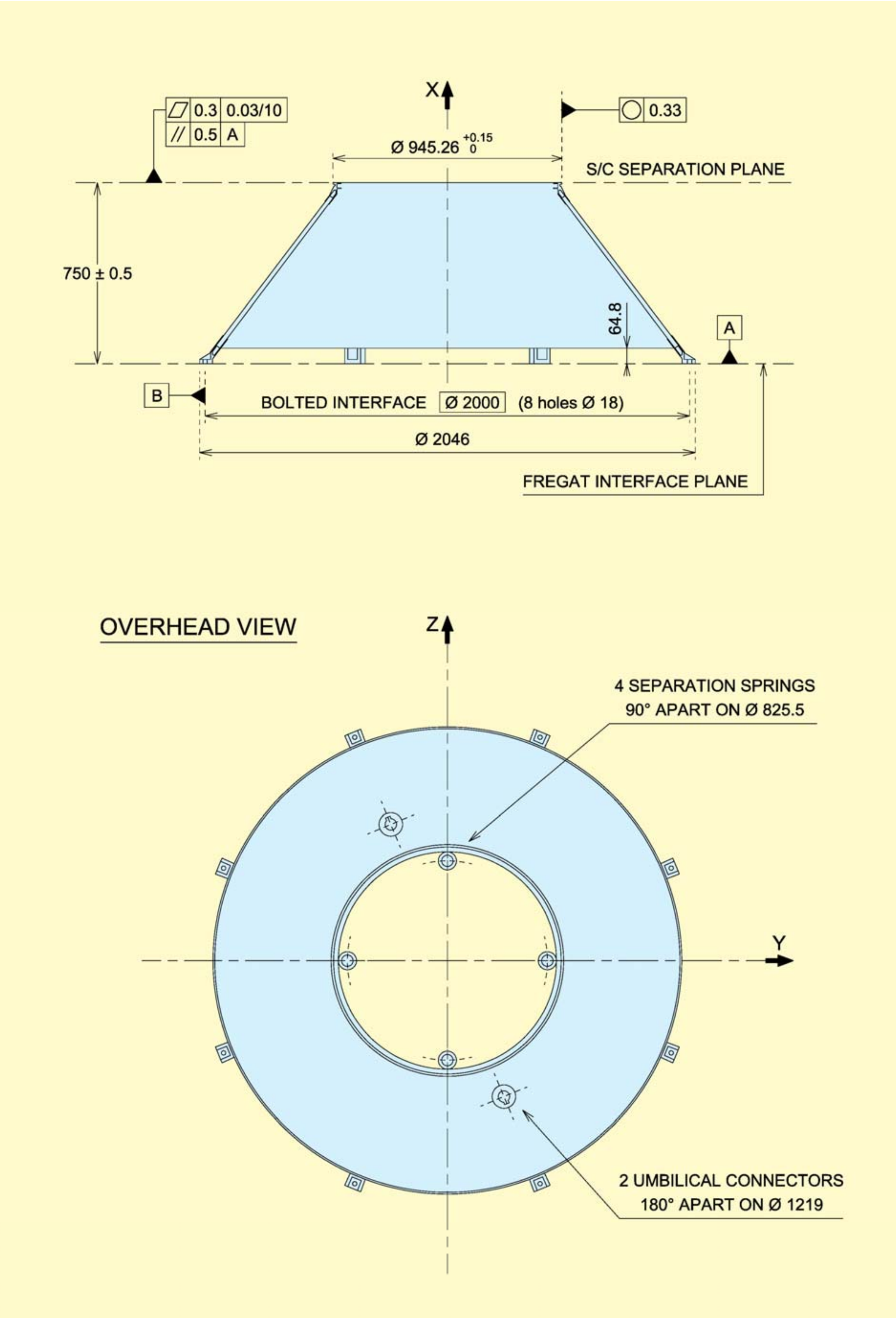
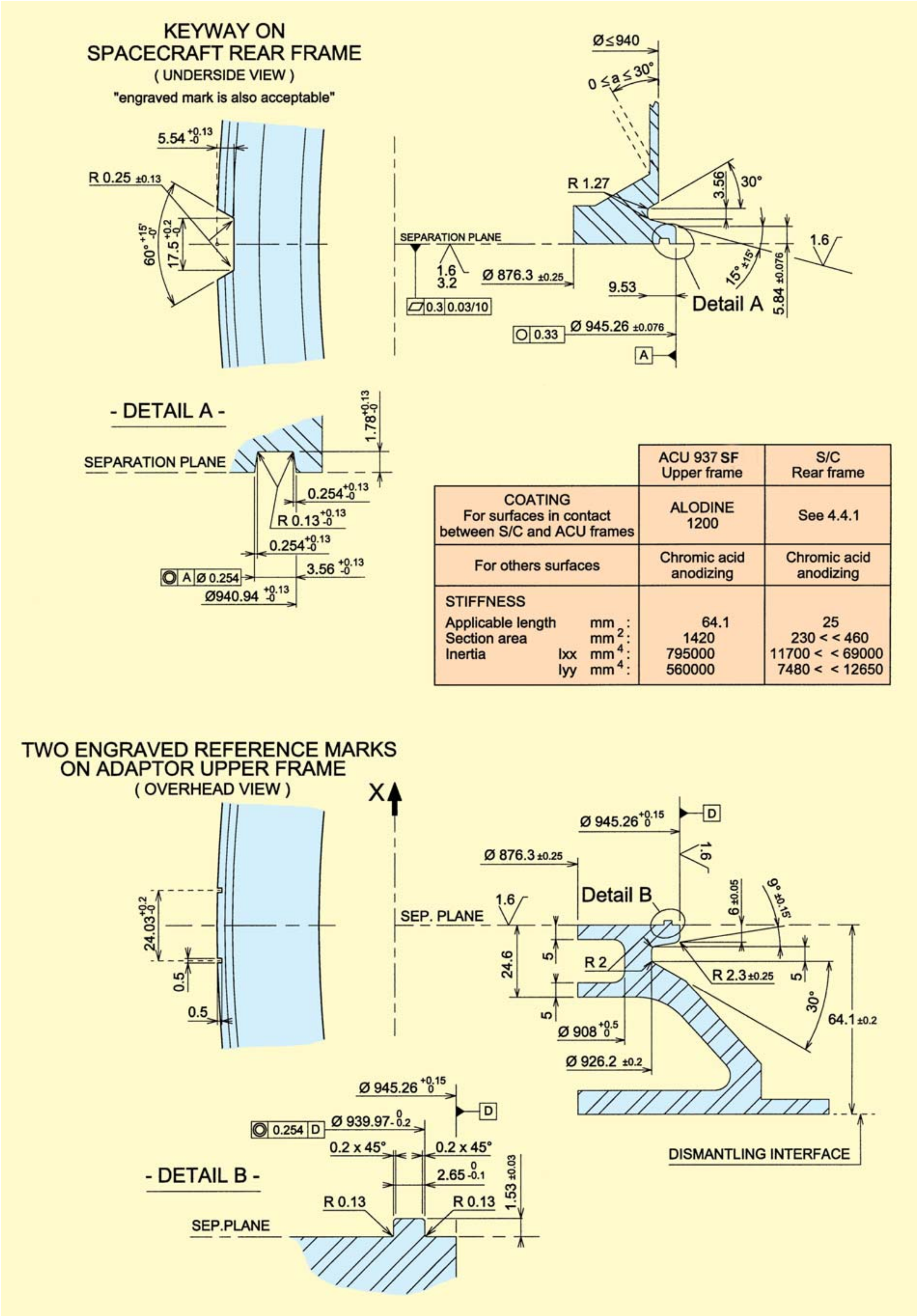



Figure A4 1-2 Adapter 937 SF – General view




| | ACU 937 SF Upper frame | S/C Rear frame |
|---|---|---|
| COATING For surfaces in contact between S/C and ACU frames | ALODINE 1200 | See 4.4.1 |
| For others surfaces | Chromic acid anodizing | Chromic acid anodizing |
| STIFFNESS | | |
| Applicable length mm : | 64.1 | 25 |
| Section area $mm^2$: | 1420 | 230 < < 460 |
| Inertia Ixx $mm^4$: | 795000 | 11700 < < 69000 |
| Iyy $mm^4$: | 560000 | 7480 < < 12650 |

Figure A4 1-3 Adapter 937 SF – Interface frames

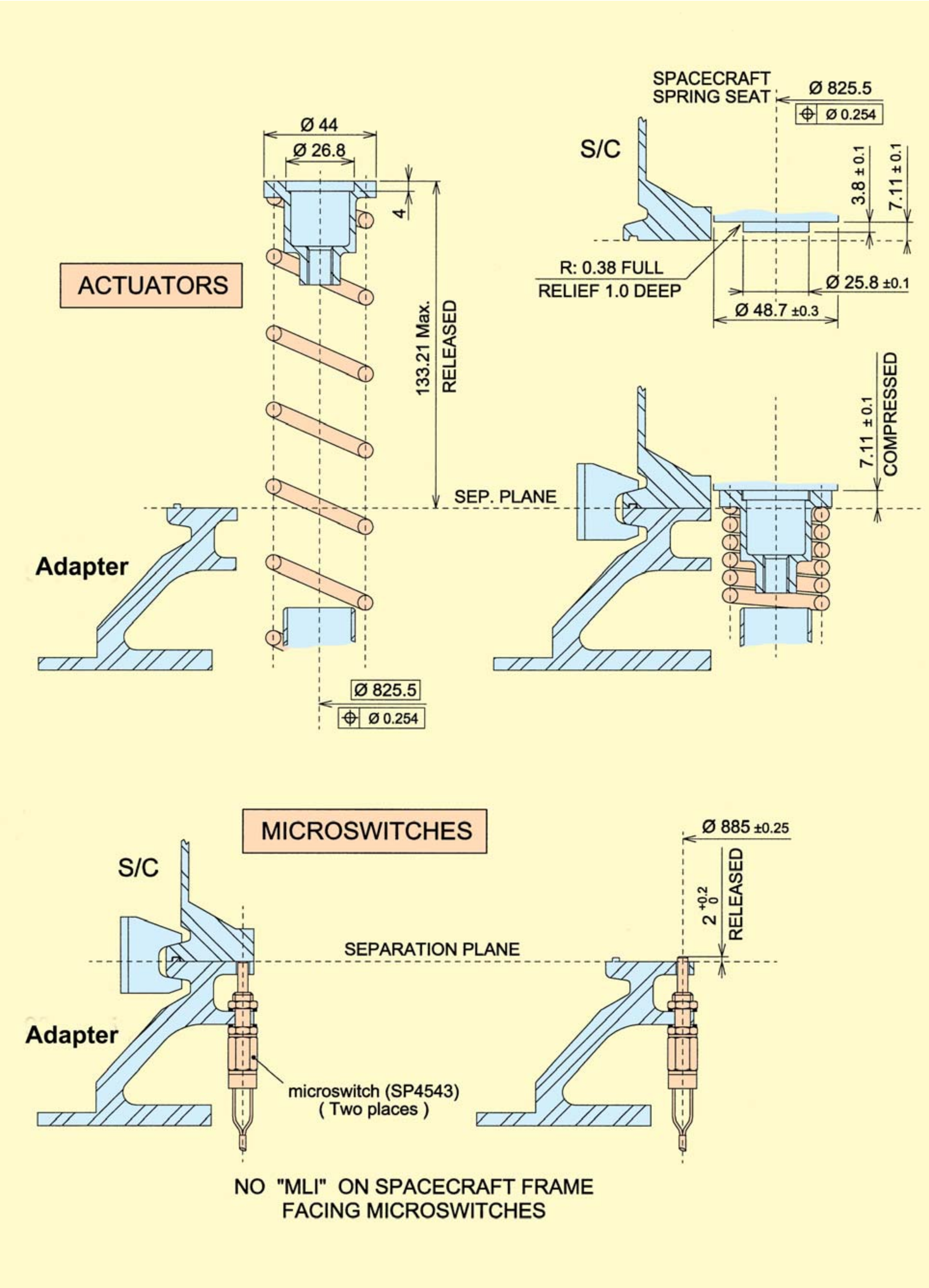



Figure A4 1-4 Adapter 937 SF – Actuators and microswitches

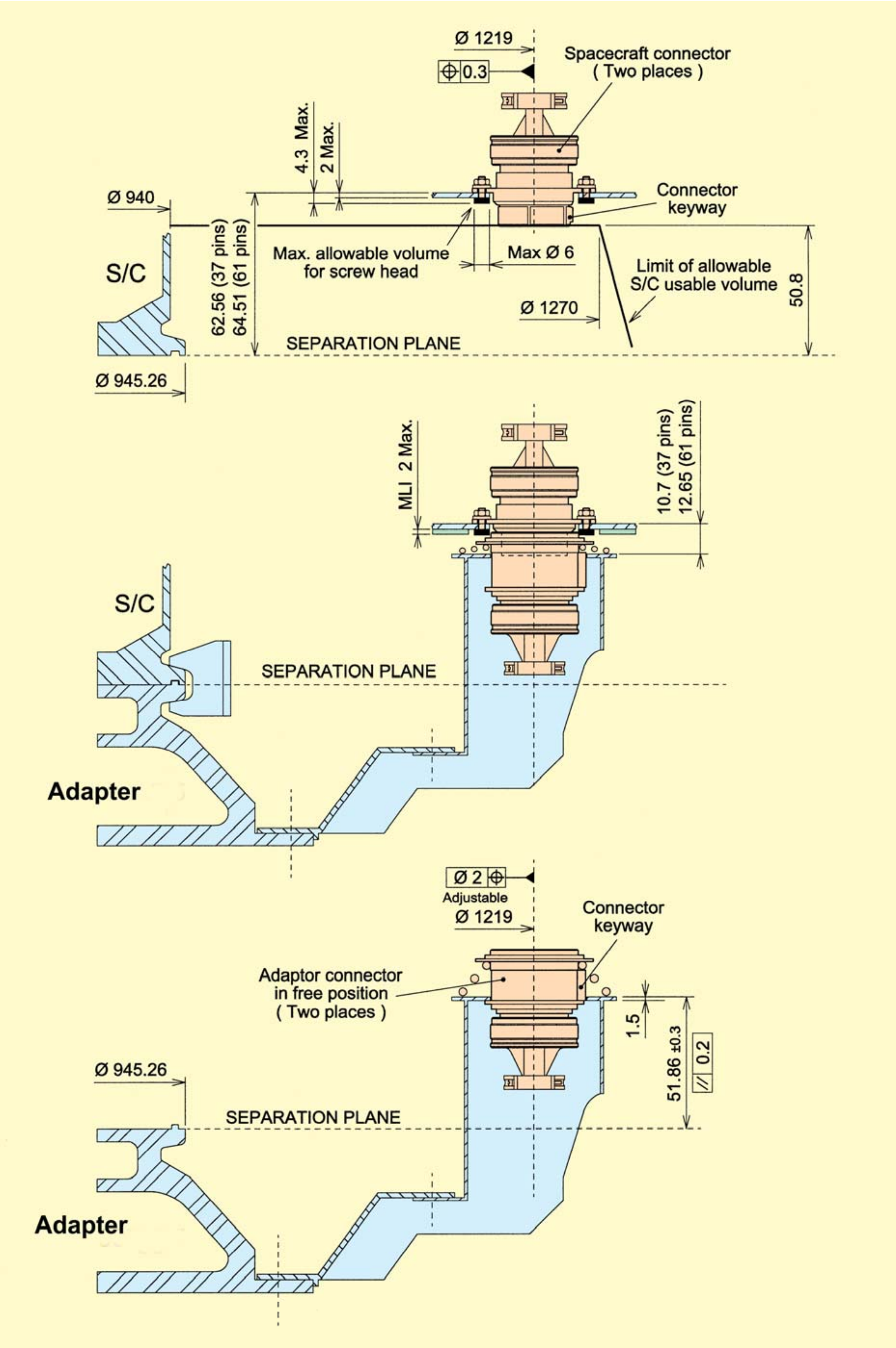



Figure A4 1-5 Adapter 937 SF – Umbilical connectors

TO BE ISSUED LATER

Figure A4 1-6 Adapter 937 SF – Usable volume

## A4.2. Adapter 1194-SF

The adapter 1194-SF was developed by EADS Launch Vehicles within the framework of the Cluster II launch services program and is currently flight-proven on the Soyuz LV (three successful flights were performed in 2000). The adapter is an aluminium monolithic structure that takes the form of a truncated cone with a diameter of 1194 mm at the level of the spacecraft separation plane (see Figure TBD). Its minimal height (230 mm) enables users to save as much space as possible in the volume under the fairing allocated to the spacecraft itself.

The adapter 1194-SF is equipped with a Saab 1194A separation system (a standard Ariane device). The spacecraft installed on top of the adapter is secured by a clamp band consisting of an iron strip that holds in place a series of clamps hooked onto the spacecraft and adapter interfacing frames (see Figure TBD). At separation, the band is severed in two places by a bolt cutter mounted on the adapter, with all pieces remaining captive to the adapter. The spacecraft is then forced away from the launcher by 4 to 12 spring actuators that are also part of the adapter and that bear on the spacecraft rear frame (see Figure TBD). In this way, the relative velocity between the spacecraft and the launcher can be adjusted to mission requirements. Once the clamp band has been installed and the springs have been released, each actuator applies a maximum force of 1200 N on the spacecraft rear frame with a ±24 N tolerance. Note that the clamp band tension does not exceed 30,100 N at any time, including dispersions due to temperature variations on ground and in flight. This ensures no gapping or sliding between the spacecraft and adapter interfacing frames during all phases of the mission.

The angular positioning of the spacecraft with respect to the adapter is ensured by the alignment of engraved marks on the interfacing frames at a specified location to be agreed on with the user.

Adapter 1194-SF is equipped with a set of sensors that are designed to monitor the spacecraft environment.

Adapter 1194-SF also holds the electrical harness that is necessary for umbilical links as well as for separation orders and telemetry data transmission from and to the Fregat. This harness will be tailored to user needs, with its design depending on the required links between the spacecraft and the launcher (see Section TBD).

Adapter 1194-SF can be used with spacecraft whose mass and CoG are below the curve provided in Figure TBD.

TO BE ISSUED LATER

Figure A4 2-1 Adapter 1194 SF – Load capability

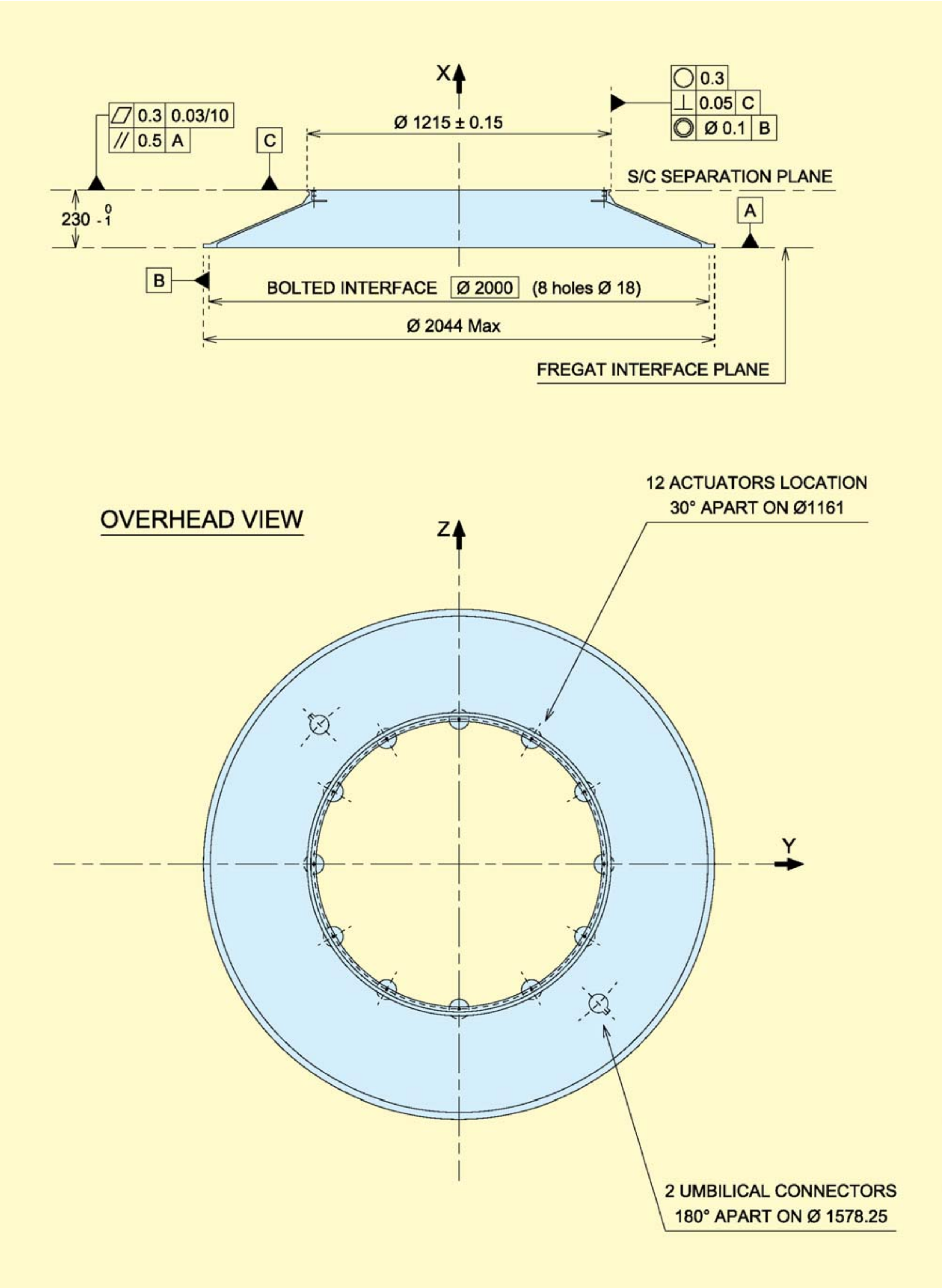
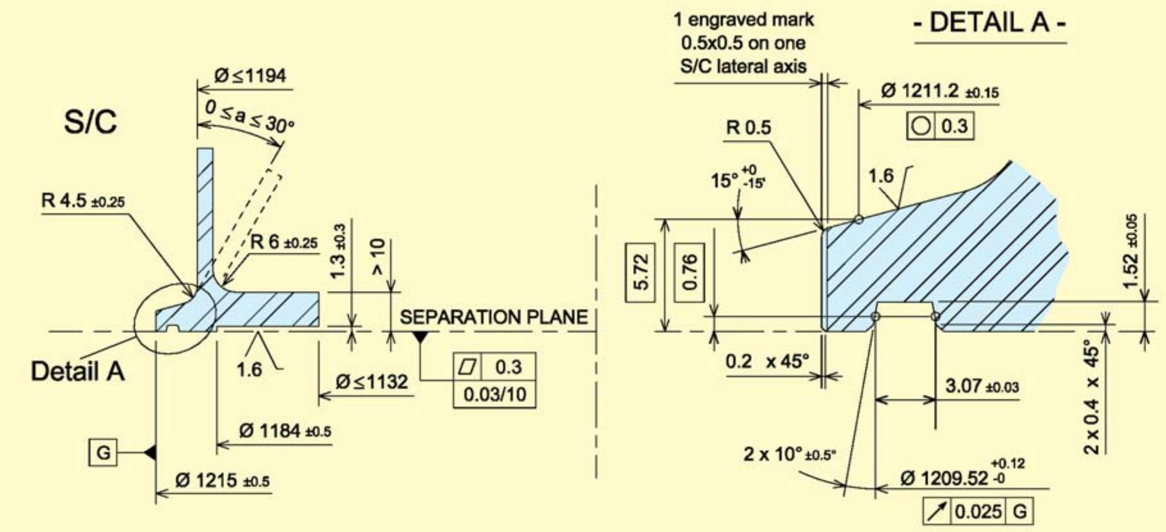



Figure A4 2-2 Adapter 1194 SF – General view




| | ACU 1194 SF Upper frame | S/C Rear frame |
|---|---|---|
| COATING<br>For surfaces in contact between S/C and ACU frames | ALODINE 1200 | See 4.4.1 |
| For others surfaces | Chromic acid anodizing | Chromic acid anodizing |
| STIFFNESS<br>Applicable length mm :<br>Section area mm$^2$ :<br>Inertia Ixx mm$^4$ :<br>Iyy mm$^4$ : | <br>25<br>-<br>-<br>- | <br>25<br>460 ± 15%<br>51000 ± 15%<br>12000 ± 15% |

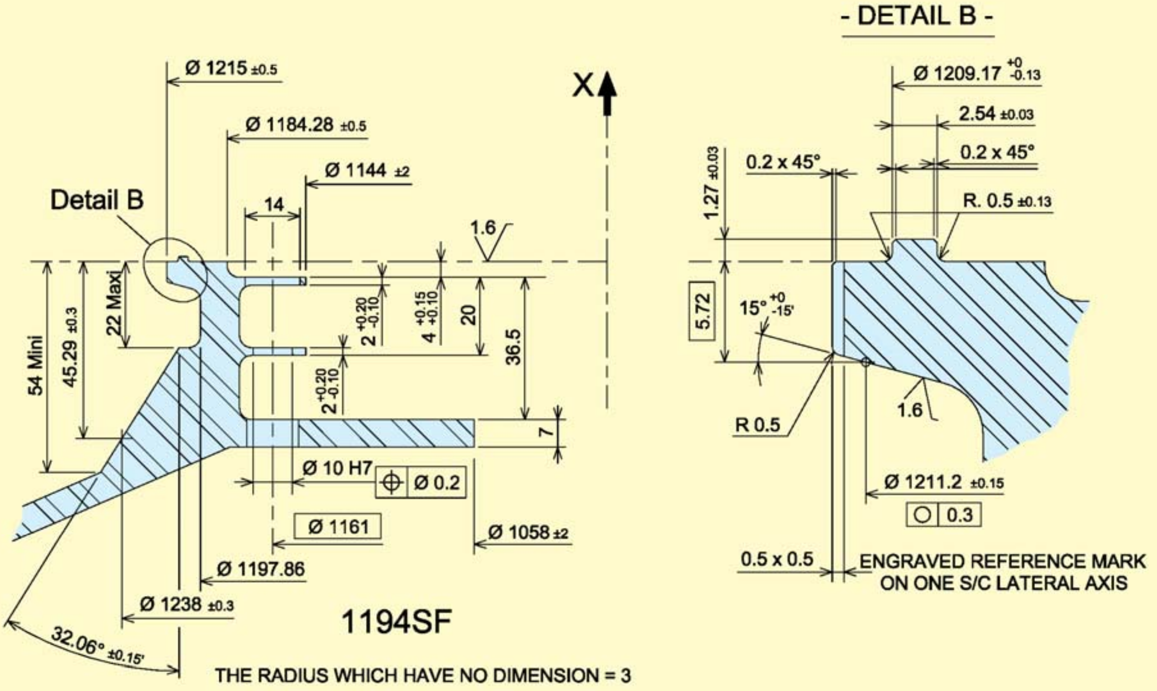



Figure A4 2-3 Adapter 1194 SF – Interface frames

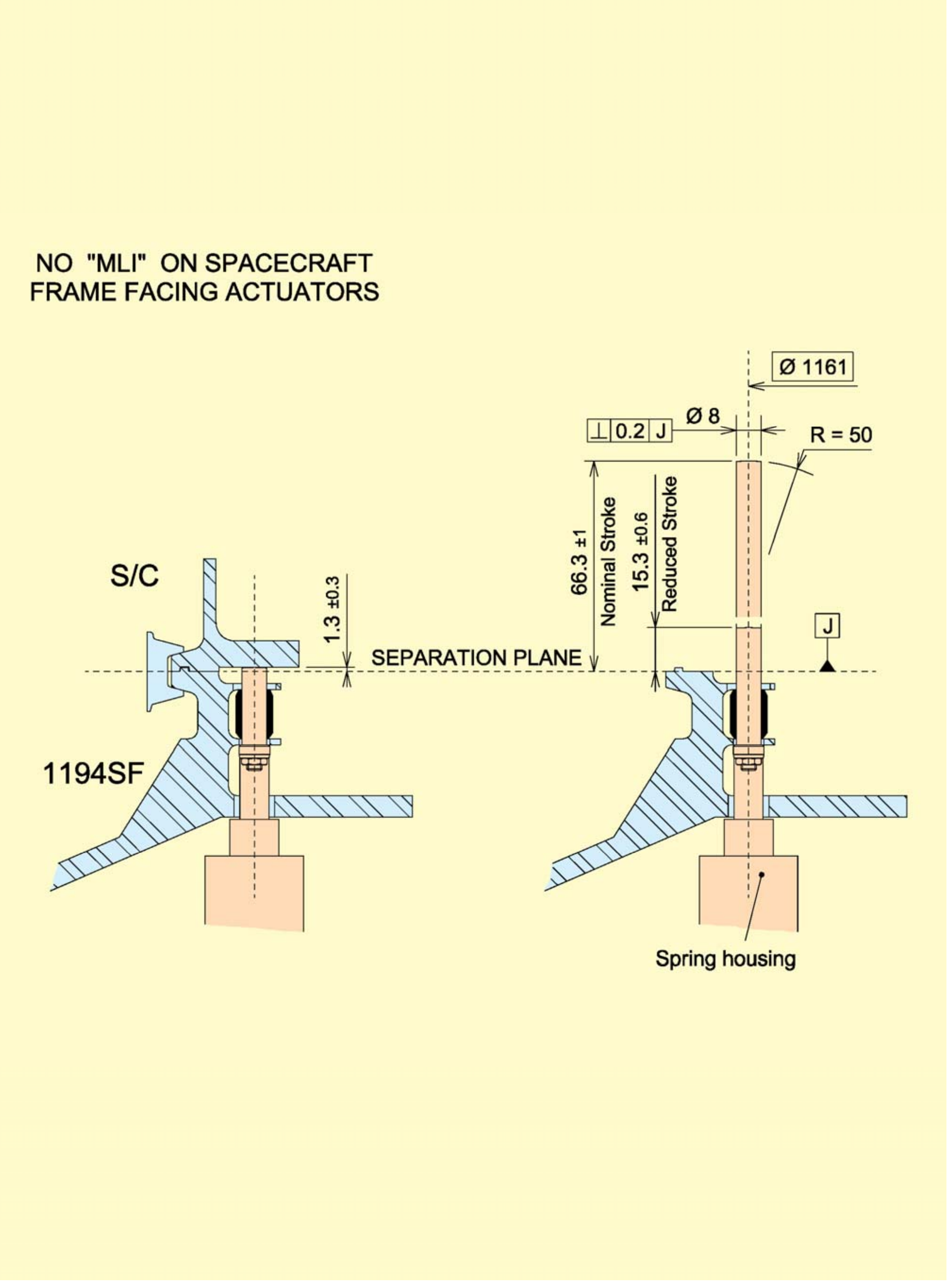



Figure A4 2-4 Adapter 1194 SF – Actuators

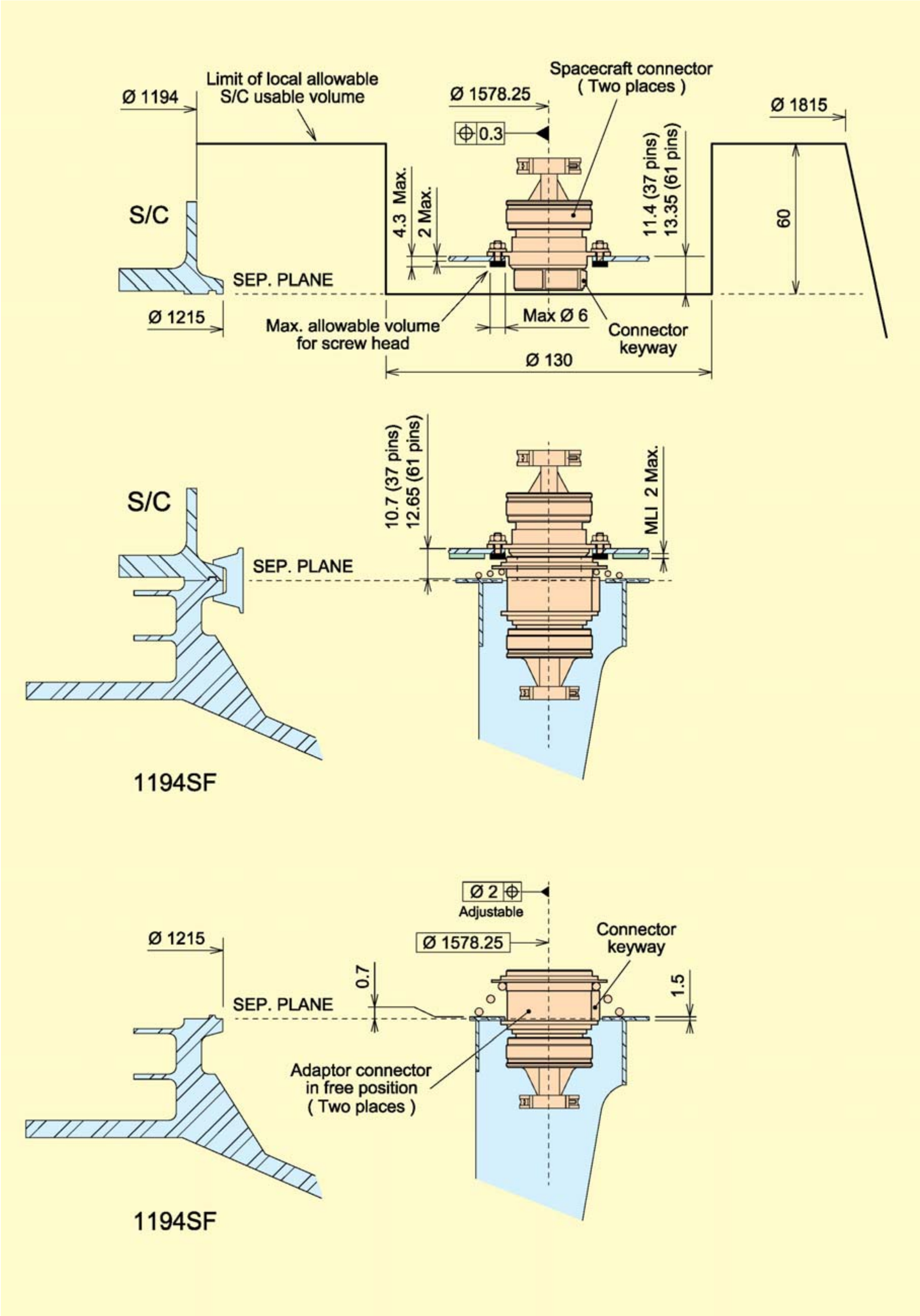



Figure A4 2-5 Adapter 1194 SF – Umbilical connectors

TO BE ISSUED LATER

Figure A4 2-6 Adapter 1194 SF – Usable volume

## A4.3. Adapter 1666-SF

The adapter 1666-SF is an aluminium monolithic structure that takes the form of a truncated cone with a diameter of 1666 mm at the level of the spacecraft separation plane (see TBD).

The adapter 1666-SF is equipped with an EADS-CASA 1666 separation. The spacecraft installed on top of the adapter is secured by a clamp band consisting of an iron strip that holds in place a series of clamps hooked onto the spacecraft and adapter interfacing frames (see Figure TBD). At separation, the band is severed in two places by a bolt cutter mounted on the adapter, with all pieces remaining captive to the adapter. The spacecraft is then forced away from the launcher by 8 spring actuators that are also part of the adapter and that bear on the spacecraft rear frame (see TBD). In this way, the relative velocity between the spacecraft and the launcher can be adjusted to mission requirements. Once the clamp band has been installed and the springs have been released, each actuator applies a maximum force of 1200 N (TBC) on the spacecraft rear frame with a ±24 N (TBC) tolerance. Note that the clamp band tension does not exceed 33,100 N (TBC) at any time, including dispersions due to temperature variations on ground and in flight. This ensures no gapping or sliding between the spacecraft and adapter interfacing frames during all phases of the mission.

The angular positioning of the spacecraft with respect to the adapter is ensured by the alignment of engraved marks on the interfacing frames at a specified location to be agreed on with the user.

Adapter 1666-SF is equipped with a set of sensors that are designed to monitor the spacecraft environment.

Adapter 1666-SF also holds the electrical harness that is necessary for umbilical links as well as for separation orders and telemetry data transmission from and to the Fregat. This harness will be tailored to user needs, with its design depending on the required links between the spacecraft and the launcher (see Section TBD).

Adapter 1666-SF can be used with spacecraft whose mass and CoG are below the curve provided in Figure TBD.

TO BE ISSUED LATER

Figure A4 4-1 Adapter 1666 SF – Load capability

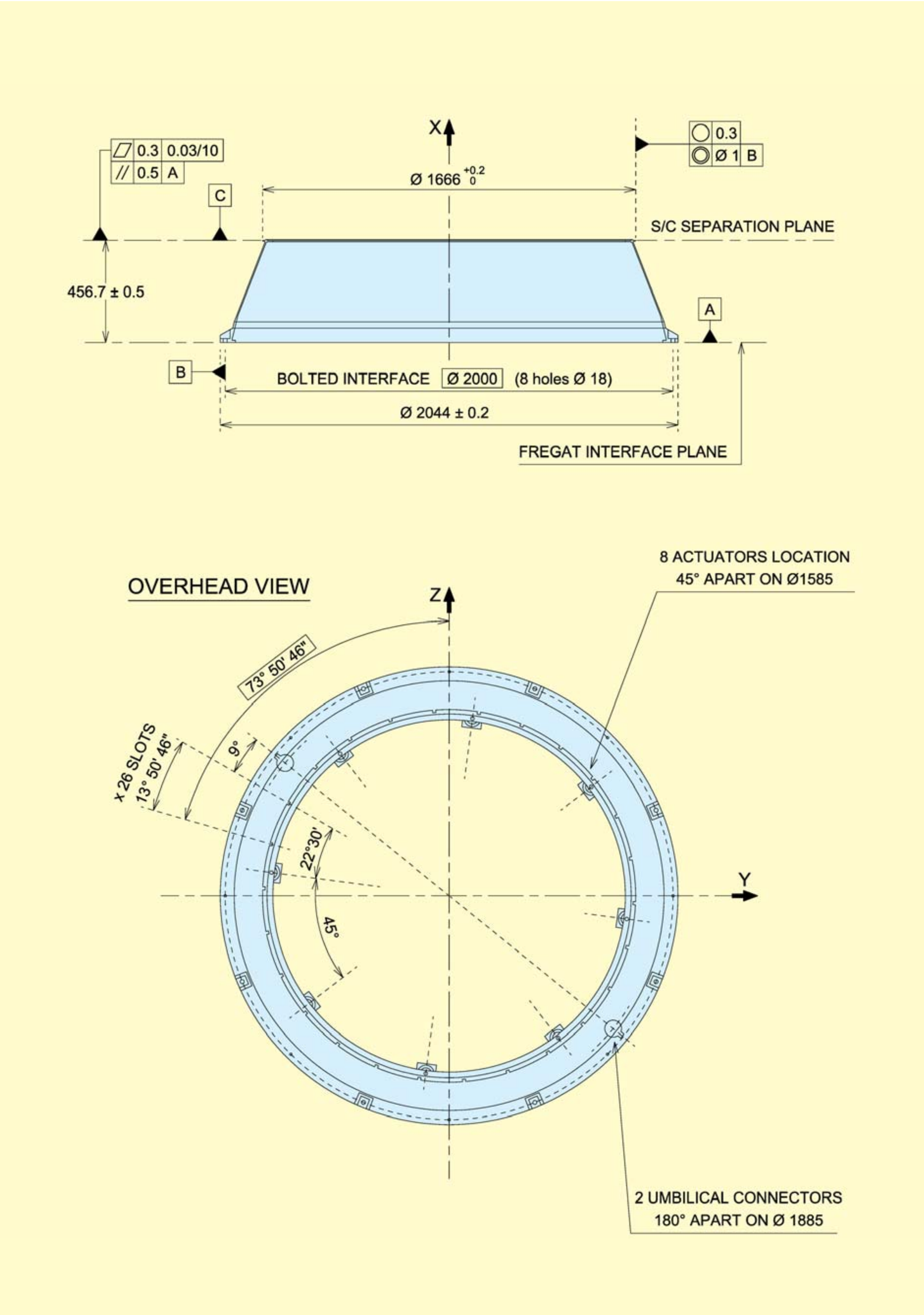



Figure A4 4-2 Adapter 1666 SF – General view

TO BE ISSUED LATER

Figure A4 2-3 Adapter 1666 SF – Interface frames

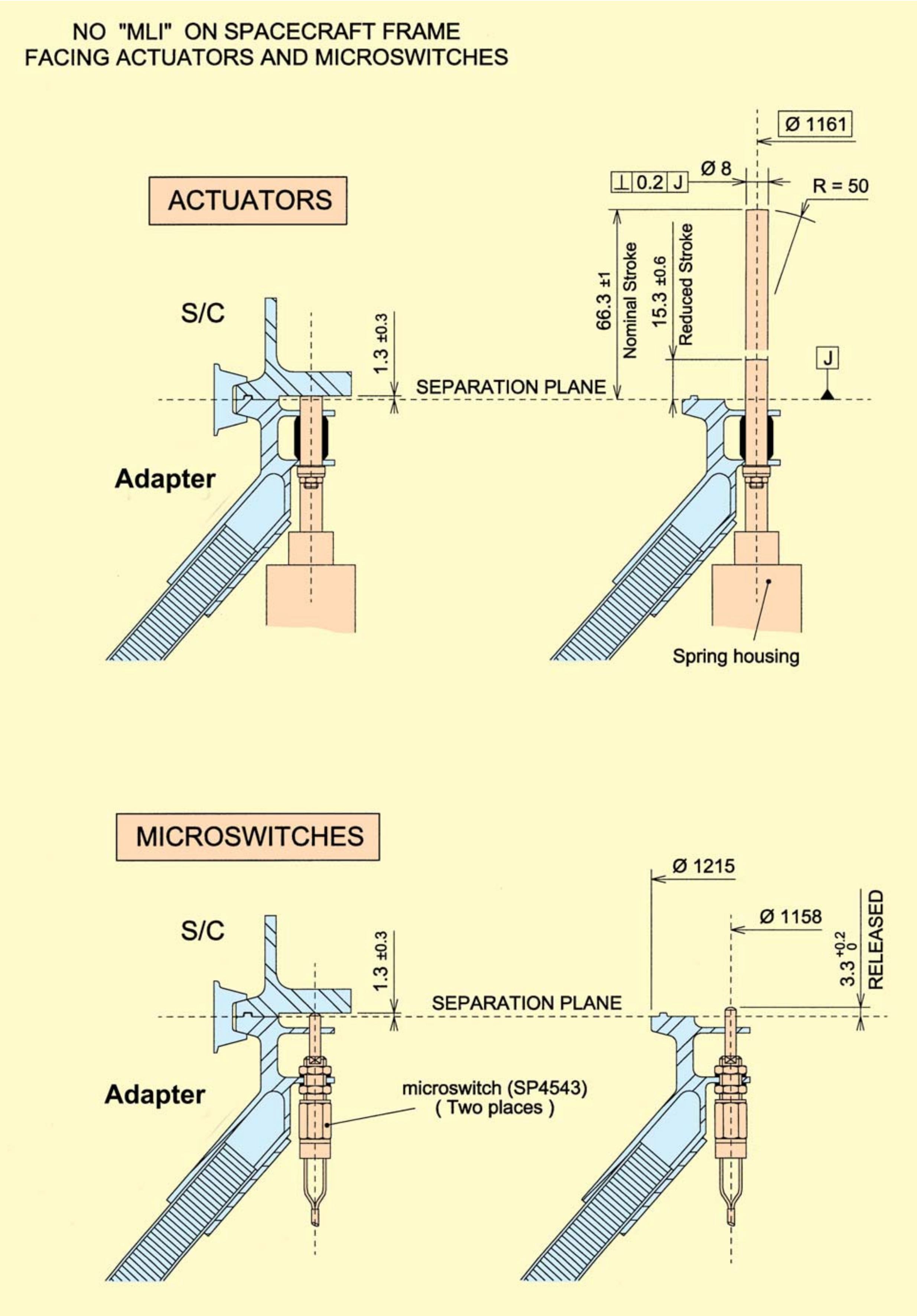



Figure A4 4-4 Adapter 1666 SF – Actuators and microswitches

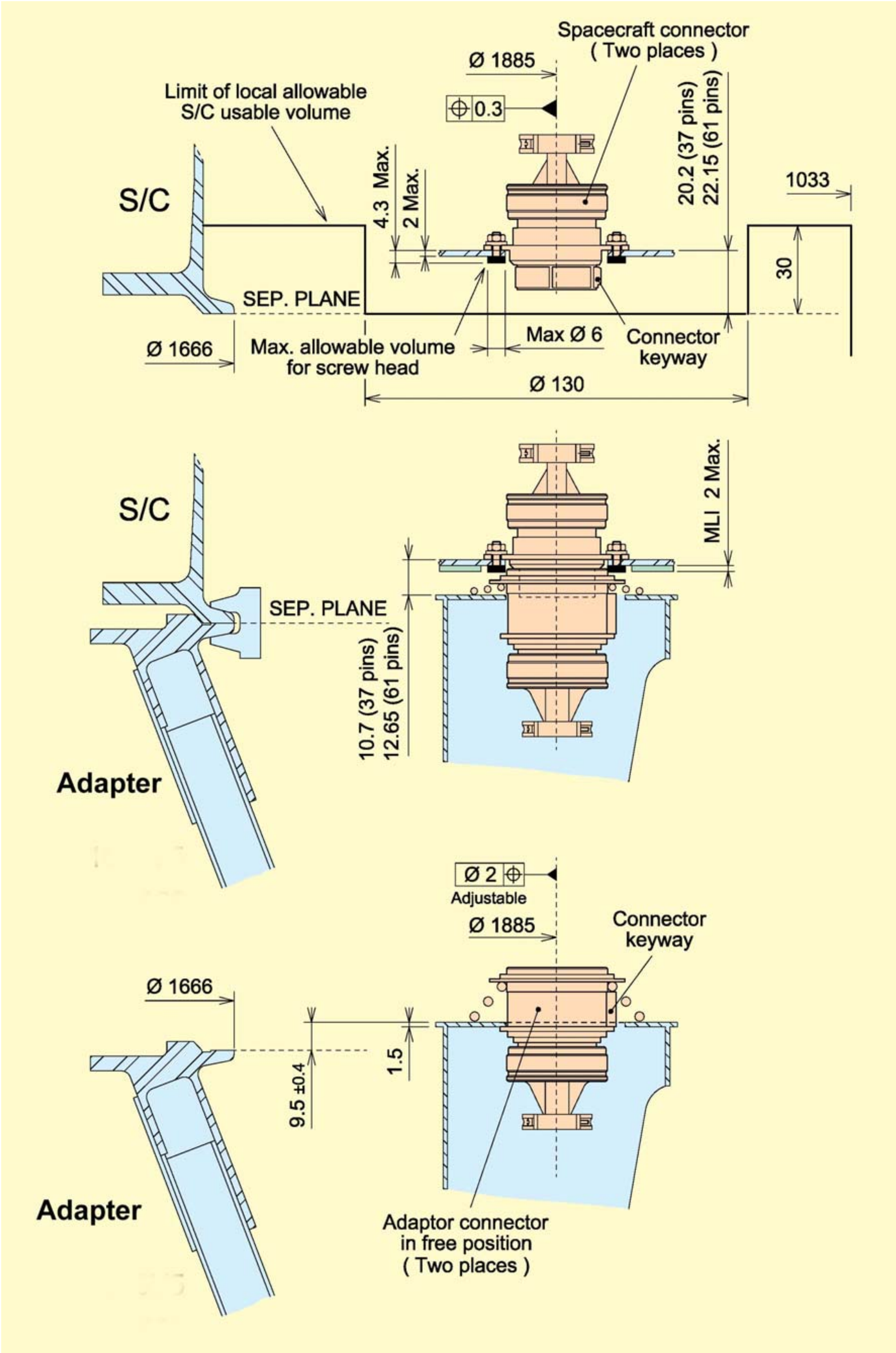



Figure A4 4-5 Adapter 1666 SF – Umbilical connectors

TO BE ISSUED LATER

Figure A4 4-6 Adapter 1666 SF – Usable volume

## A4.4. Dual launch structure

An internal dual launch carrying structure, similar in its principle to the Ariane SYLDA, is being developed to offer dual launch opportunities. The usable volume offered by this structure is presented in Chapter 5.3.4.

Customers interested by this launch configuration are requested to contact Arianespace to get further details.

## A4.5. Dispenser

Dispensers are specific interface structures that are devoted to satellite constellation deployment and that allow for the handling and separation of at least two spacecraft per launch. As mission requirements and constraints differ significantly from one constellation to another, such structures are generally mission-specific and thus cannot be considered off-the-shelf devices. Consequently, the information provided below with regard to the Globalstar dispenser is intended mainly to present Arianespace's ability to manage the development, qualification, and recurrent manufacture of this type of structure. Such experience would obviously be of benefit to other satellite constellation programs, as most of the principles involved — especially those related to the handling and separation system — are valid for any application.

The Globalstar (GLS) dispenser was developed by EADS within the framework of the Globalstar launch services agreement and was successfully flown six times on the Soyuz Ikar launch vehicle in 1999. It is an aluminum structure capable of handling four 450-kg satellites and of providing these satellites with the required separation impulse once in orbit. It consists of the following (see Figure TBD):

- A conical part that interfaces with the Ikar upper frame;
- A cylindrical part that interfaces with three of the four spacecraft; and
- A top plate that interfaces with the fourth spacecraft.

Each spacecraft had four contact points with the dispenser. These points are located at the corners of a 598 mm x 1650 mm rectangle. The separation subsystem thus consisted of four assemblies, each comprising four pyro bolts, four spring actuators, and two microswitches. The release shock spectrum at the spacecraft/adapter interface is indicated in Figure TBD.

The Globalstar dispenser was equipped with a set of sensors that are designed to monitor the spacecraft mechanical environment, thereby enabling users to verify the compliance of acoustic pressure, QSLs, and sine and random vibrations against the levels indicated in the Interface Control Document. All sensor outputs were processed by the Ikar telemetry system.

The Globalstar dispenser also held the electrical harness necessary for umbilical links as well as for separation orders and telemetry data transmission from and to the Ikar. This harness was tailored to Globalstar's needs and included the transmission of spacecraft battery temperature and voltage up to separation. The Globalstar dispenser mass was 391 kg.

TO BE ISSUED LATER

Figure A4 7-1 Typical dispenser – General view

# LAUNCH VEHICLE DESCRIPTION Annex 5

## A5.1.Launch vehicle Description

### A5.1.1. General data

The Soyuz LV consists of:

- A lower composite consisting of four liquid-fueled boosters (first stage), a core (second) stage, and a third stage;
- A restartable Fregat upper stage;
- A payload fairing and interstage section; and
- A payload adapter/dispenser with separation system(s).

The Fregat, adapter and spacecraft are all contained within the fairing representing the Upper Composite of the launch vehicle.

Depending on mission requirements, a variety of different adapters/dispensers may be used.

The Soyuz launch vehicle in the present configuration is in operation since 1966 except for the Fregat upper stage that was introduced in 2000.

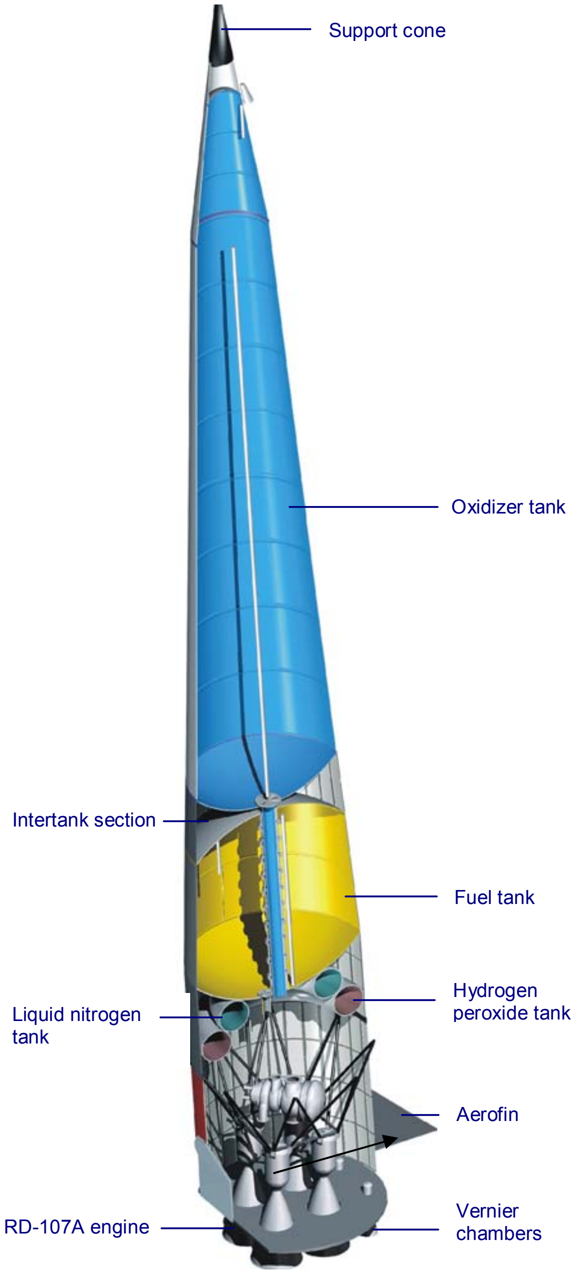
Since 1966, a few improvements were introduced to the Soyuz Launch vehicle to increase the safety and reliability of the vehicle and, at the same time, increase the performance of the launcher. The latest improvements that were introduced to the Soyuz Launch System from 2000 to 2005 include:

- Amelioration of the propellant burning in the chambers of the 1st and 2nd stage engines (Soyuz FG): current configuration for the manned flights;
- Replacement of the analogic control and telemetry systems by the digital ones (flown in 2004: Soyuz 2-1a);
- Introduction of a larger fairing (4.110 m in diameter and 11.433 m in length);
- Non-critical ameliorations of the Fregat dry mass, propulsion management and electrical components ;
- Amelioration of the 3rd stage layout adapted to the implementation of two different types of engine: RD-0110 (current version) and RD-0124 (more powerful version)

The launch conditions at GSC impose a few minor adaptation of the Launch Vehicle system to cope with the specific French Guiana environment and safety regulations, in particularly:

- Adaptation of the Soyuz and Fregat telemetry systems to cope with the S-band and IRIG specification of the CSG ground stations,
- Adaptation to the French Guiana climatic conditions, in particular, tuning the launcher air-conditioning system to the Guiana temperature and humidity,
- Adaptation, to comply with the CSG safety regulations, to be able to send from the ground a telecommand to shut down the engines in case of major anomaly during the flight in addition to the automatic one presently used on Soyuz.

## A5.1.2. Boosters (First Stage)




The four boosters are arranged around the central core and are tapered cylinders with the oxidizer tank in the tapered portion and the kerosene tank in the cylindrical portion (see Figure A5- 1). As in the entire Soyuz lower composite, the RD-107A engines of the boosters are powered by nontoxic liquid oxygen – kerosene propellants. These spark-ignition engines are fed by a turbopump running off gases generated by the catalytic decomposition of $H_2O_2$ in a gas generator. Each RD-107A has four combustion chambers and nozzles. Liquid nitrogen is used for pressurization of the propellant tanks.

Attitude control is carried out through two movable vernier thrusters and one aerofin. Three-axis flight control is made possible through these eight engines (two per booster) and four aerofins (one per booster).

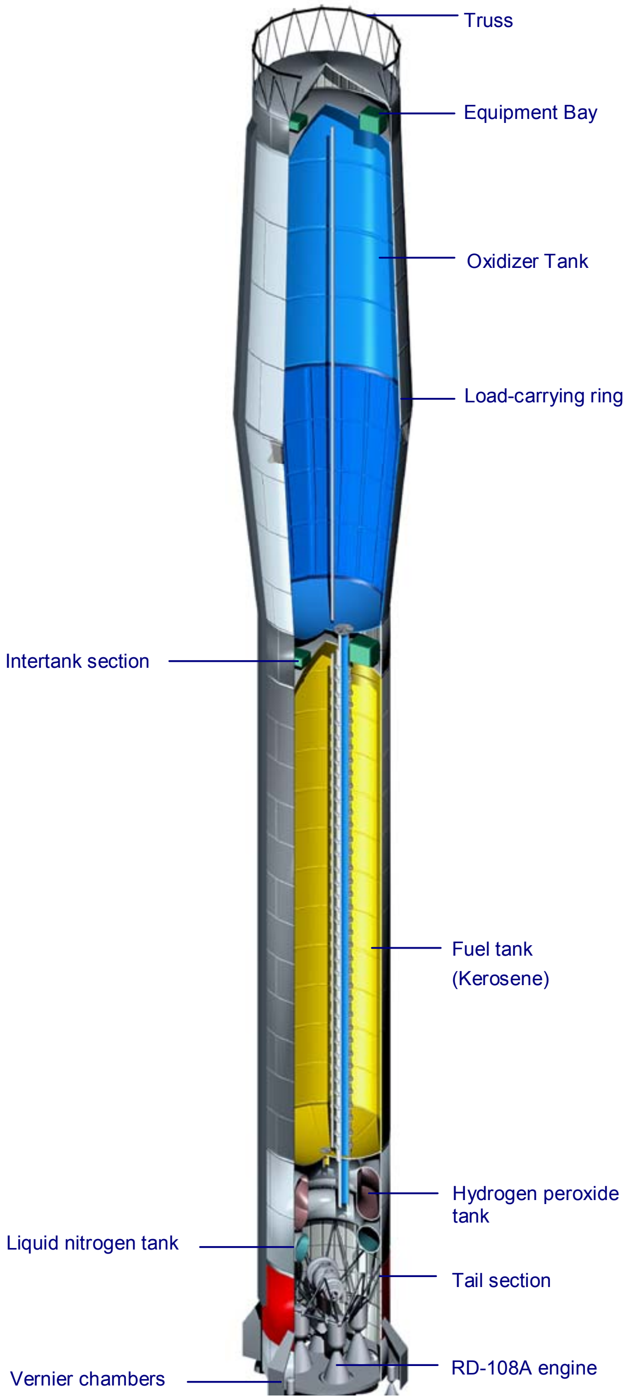
The boosters burn for 118 seconds and are then discarded. Thrust is transferred through a ball joint located at the top of the cone-shaped structure of the booster, which is attached to the central core by two rear struts.

Figure A5- 1 : Booster Layout and Location

## A5.1.3. Core (Second Stage)

The second stage is similar in construction to the booster stages, using the RD-108A engine and four vernier thrusters for three-axis flight control (see Figure A5- 2). The core stage nominally burns for 290 seconds. The stage is shaped to accommodate the boosters, and a stiffening ring is located at the upper interface between the boosters and central core. This structure is strengthened with use of larger fairing

The boosters and the central core are ignited on the ground. They burn at intermediate thrust levels for approximately 20 seconds before actual liftoff in order to verify their health and nominal level of operation. The core stage continues to function after booster shutdown and separation.



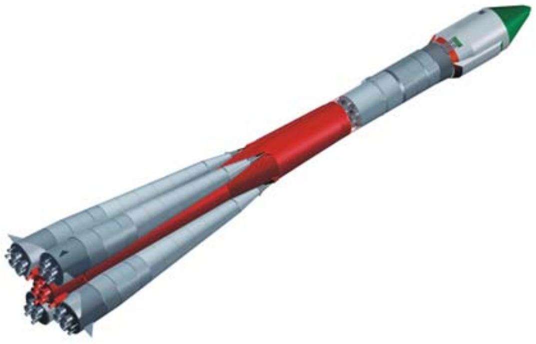
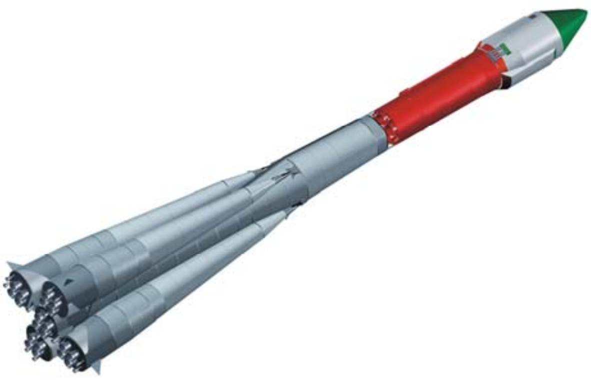



Figure A5- 2 : Core Stage Layout and Location

## A5.1.4. Third Stage



Ignition of the third stage's single main engine occurs approximately 2 seconds before shutdown of the central core. The separation of the stages takes place at a predetermined velocity. After separation, the lower skirt of the third stage is jettisoned in three sections.

The third stage of the Soyuz is powered by the RD-0110 engine (see Figure A5-3). The LOX and kerosene tanks will be modified to accommodate the more powerful RD-0124 engine. In fact, since the RD-0110 and RD-0124 engines have the same thrust, the same stage structure can accommodate both.

The RD-0110 engine is powered by a single turbopump spun by gas from combustion of the main propellants in a gas generator. These combustion gases are recovered to feed four vernier thrusters that handle attitude control of the vehicle. The LOX tank is pressurized by the heating and evaporation of the oxygen, while the kerosene tank is pressurized by combustion products from the gas generator.

The RD-0124 engine is a staged combustion engine powered by a multi-stage turbopump spun by gas from combustion of the main propellants in a gas generator. These oxygen rich combustion gases are recovered to feed the four main combustion chambers where kerosene coming from the regenerative cooling circuit is injected. Attitude control is provided by main engine activation along one axis in two planes. LOX and kerosene tanks are pressurized by the heating and evaporation of helium coming from storage vessels located in the LOX tank.

An interstage truss structure connects the core stage with the third stage, thereby allowing for the ignition of the third stage before separation of the second. In fact, this ignition assists the separation of the second stage.

For deorbitation and collision avoidance, a reaction nozzle is positioned on the side of the stage and vents the oxygen tank.

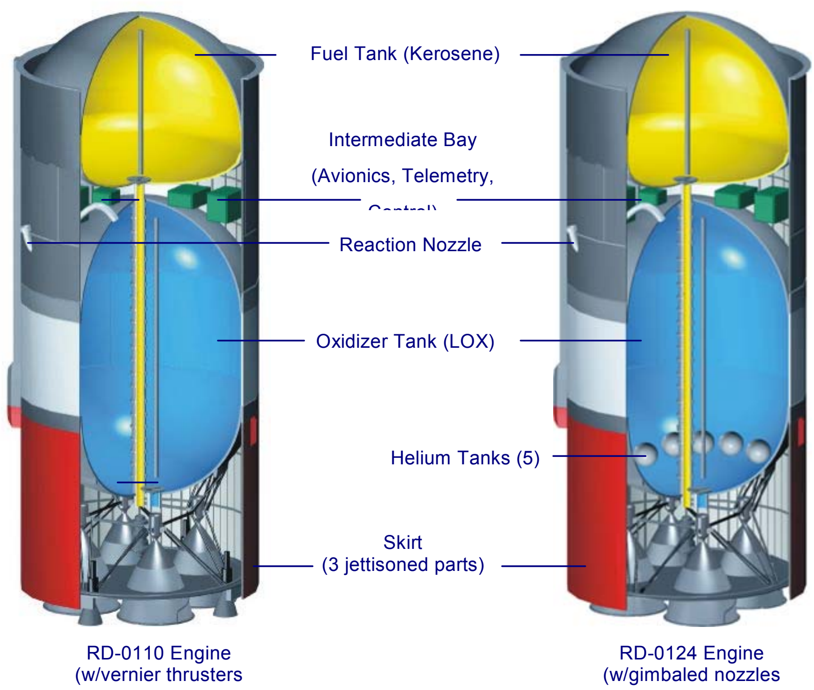



Figure A5- 3 : Third Stage with RD-0110 and RD-0124 engines

## A5.1.5. SOYUZ avionics

### A5.1.5.1. Control System

The control system performs the following functions for flight of the first three stages of the Soyuz:

- Attitude control/stabilization;
- Navigation and guidance; and
- Vehicle management, including health monitoring, propellant control and monitoring, and delivery of pyrotechnic commands.

The control system of the Soyuz operated from the CSG is based on a digital computer and four-axis gimbaled inertial measurement units (IMU), communicating through the digital bus with other sub-systems and actuators through analog/digital converters. Most of the front-end equipment remains identical to the conventional design ones. The navigation parameters comes from the IMU and from GPS/GLONASS receivers.

The control system is unique for the first three stages and is located primarily in the equipment bay of the third stage (IMU and digital computer).

The system uses a triplex architecture with a 2 out of 3 voting logic. The IMU and on-board computer are based on mature Russian missiles technology.

The use of a digital control system provides:

- Improved flexibility and efficiency of the flight.

  The Soyuz attitude control system (ACS) is capable of handling the aerodynamic conditions generated by the larger fairing.

  The Soyuz is able to perform in-flight roll maneuvers as well as in-plane yaw steering (dogleg) maneuvers.

- Improved accuracy

  The use of an IMU provides the vehicle with more accurate navigation information, and the computer allows to recover from deviations in the flight path. Introduction of a satellite-based navigation (GPS) update during the ascent flight can serve to mildly correct any drift or inaccuracies in the IMU measurements, and further refine the accuracy of the initial injection orbit.

  In any case, it should be noted that the Fregat (with its own independent IMU and on-board computer) corrects inaccuracies resulting from the ascent flight profile. However, the advantage of a more accurate lower composite flight will result in a lower propellant consumption of the Fregat to correct the errors, and an actual improvement on certain orbits (especially LEO).

### A5.1.5.2. Telemetry

A digital telemetry system with transmitters operating in S band, compatible with CSG ground network, is located in the equipment bay of the third stage of the Soyuz. The health-monitoring parameters are downlinked to ground stations along the flight path. Data are transmitted from ground stations to a Mission Control Center where they are analyzed and recorded, some in real time.

### A5.1.5.3. Tracking

The launch vehicle position determined by the IMU and is downlinked to the ground through the telemetry system. In addition, one independent GPS/GLONASS receiver elaborates the position of the launcher and transfers it to the ground every second through the same telemetry system. The redundant tracking system, based on transponder compatible with CSG ground station, is used independently.

### A5.1.5.4. Range Safety

The Soyuz launched from the CSG uses proven logic of automatic on-board safety system. The anomalies, such as exceeded limits on selected parameters, or unexpected stage separation, are detected by the on-board control system that triggers the shut down of all engines and ballistic fall of the vehicle back to earth.

An additional flight abort system, of Ariane type, has been added to allow to shut down the launch vehicle engines by a remote command sent from the ground.

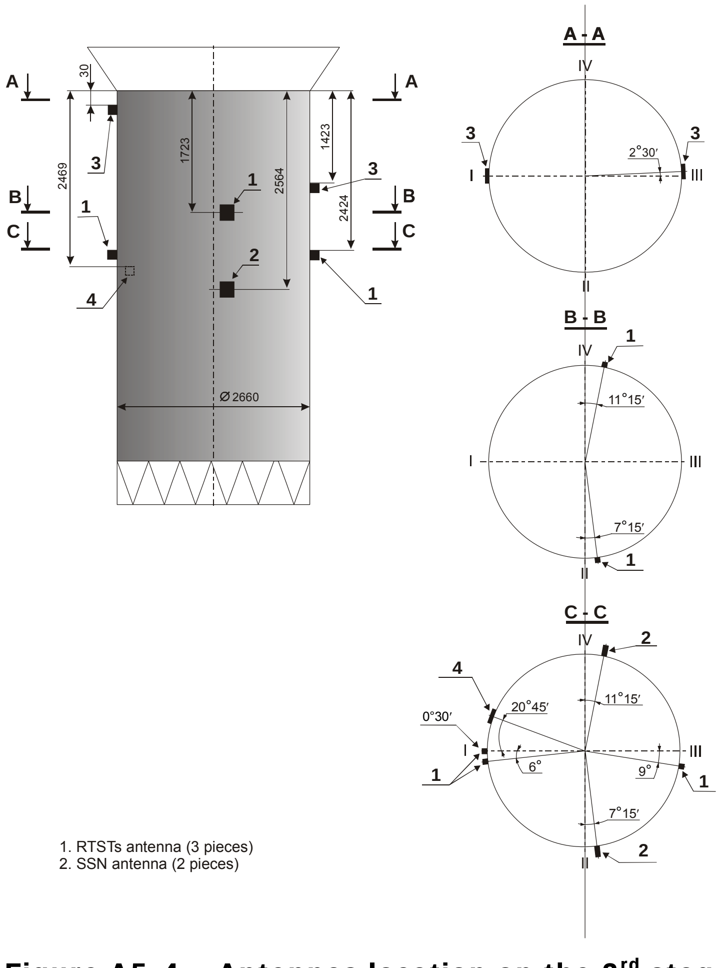



**Figure A5-4 – Antennas location on the 3rd stage**

### A5.1.6. Fregat Upper Stage

The Fregat upper stage is an autonomous and flexible stage designed to operate as an orbital vehicle. It extends the capability of the lower three stages of the Soyuz vehicle to provide access to a full range of orbits.

The upper stage consists of six welded 1.8 mm thick spherical tanks, made of aluminum alloy (AMG-6) (four for propellant, two for avionics) distributed in a circle, with 8 trusses passing through the tanks providing structural support. The propulsion system consists of a single chamber NTO / UDMH engine capable of in-plane translation, and controlled by electrohydraulic actuators.

In addition to the main engine, FREGAT uses twelve thrusters for three-axis attitude control, and for propellant settling before ignition of the main engine. The thrusters are distributed in 4 clusters on the top of the spherical tanks. Up to 85 kg of hydrazine is stored in two tanks dedicated to the ACS.

The three axis inertial measurement unit, the onboard computer and the GPS/GLONASS navigation system form the core of the FREGAT control system. The control system is based on a triple-redundant architecture. Both three-axis stabilized orientation and spin-stabilized modes are provided.

Telemetry system provides transfer of health monitoring data from FREGAT to the ground, either via a direct transmission mode or via a playback mode. The S-band transmitter enables communication with CSG ground stations.

The FREGAT power supply consists of two Lithium-Chloride batteries. One battery is dedicated to the control system only; the other is dedicated to the remaining equipment. The number of batteries can be increased according to mission duration.

The thermal control system of the two equipment bays consists of two dedicated fans for nitrogen circulation. Thermal insulation and heaters protect the external equipment and the propellant tanks.

The Fregat is presented in Figure A5- 4.

The Fregat is a restartable upper stage (main engine with multiple-ignition capability up to 20 times, with six demonstrated during flight), fully independent from the lower composite (IMU, telemetry, power, etc.),which allows a wide range of missions and even to be potentially compatible with other launch vehicles.

NPO Lavotchkine, located near Moscow, is responsible for the production of Fregat. Its facilities can accommodate the production of up to eight upper stages per year with a production time of 10 to 15 months.

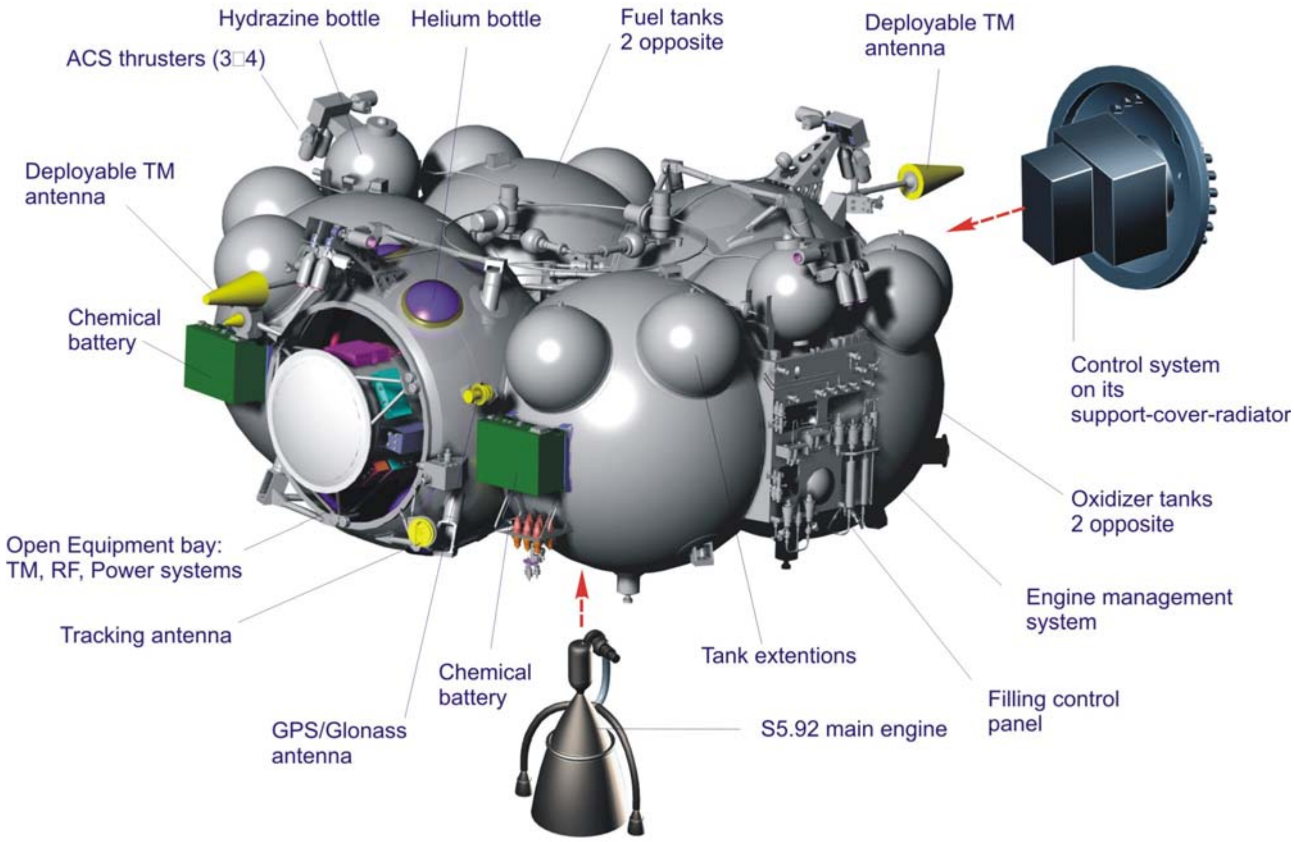



Figure A5- 5 : Fregat Overview

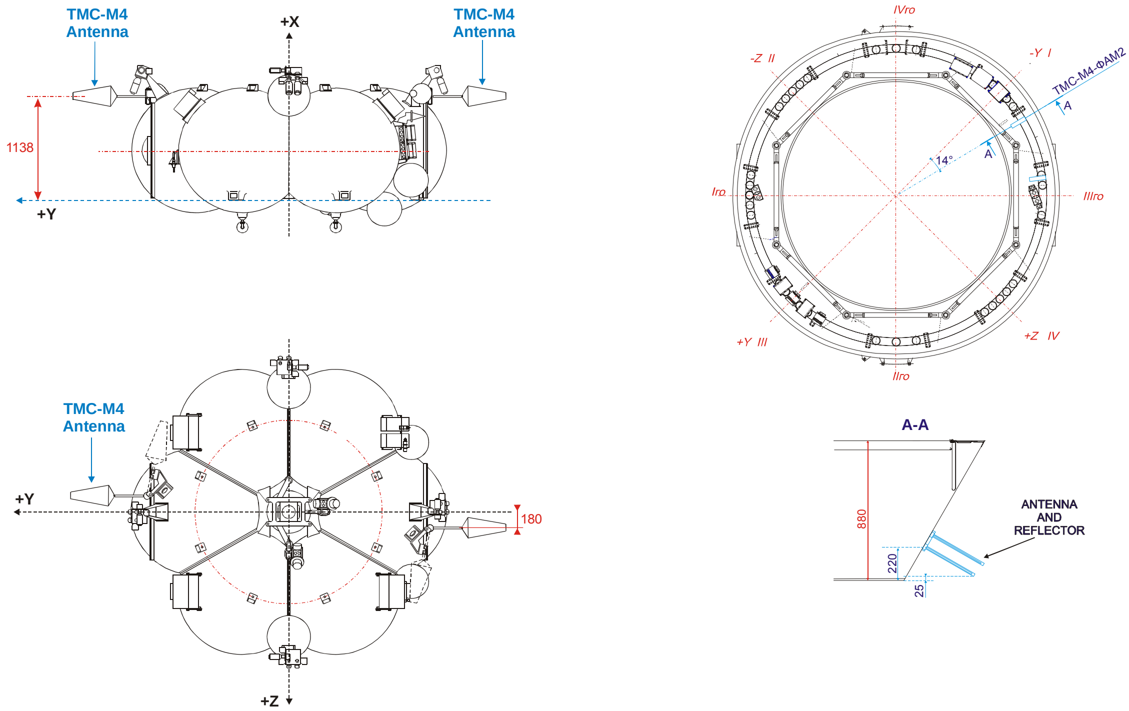



Figure A5-6 – Antennas location on the Fregat

# A5.2.LAUNCH VEHICLE HISTORY / RECORD

## A5.2.1. Soyuz Family of Launch Vehicles

The two-stage R-7A intercontinental ballistic missile (ICBM) laid the groundwork for an evolutionary series of launch vehicles that would eventually launch the world's first satellite (Sputnik, 1957) and man (Yuri Gagarin, 1961) into space. Originally developed by Sergei Korolev's OKB-1 design bureau (now RSC Energia) in Kaliningrad, the R-7A was the first in a series of vehicles that, in addition to the Soyuz, includes: Sputnik, Vostok, Molniya, and Voskhod. Since the R-7A was developed between 1953 and 1957, some ten different versions have been built in this family.

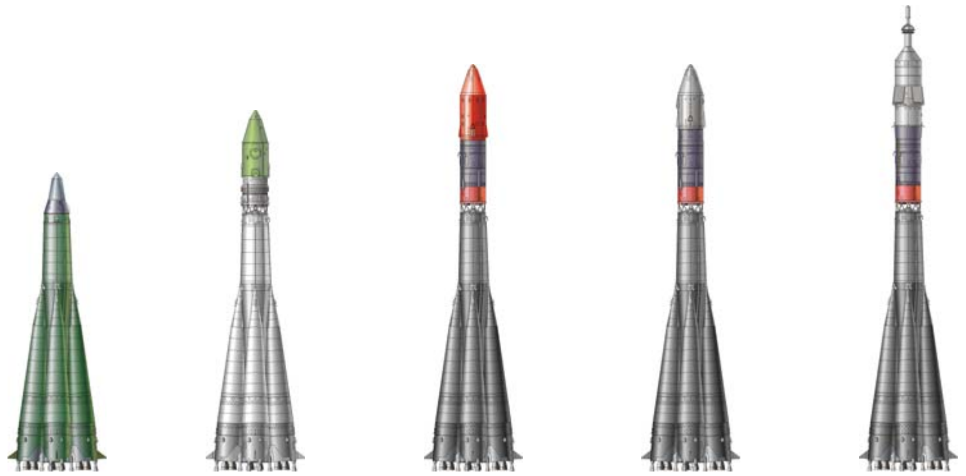
Production of the R-7A was moved to the Progress Aviation Factory in Samara, Russia, now the production facility of TsSKB-Progress, beginning in 1959. Over time, complete responsibility for the family would pass from Kaliningrad to Samara, with the design facilities at Samara transforming from a subsidiary of OKB-1 to an independent entity (TsSKB) in 1974. Since then, TsSKB and the Progress factory have been in charge of design, development, and production of vehicles in this family and their future derivatives. They were combined into one entity, Samara Space Center "TsSKB-Progress", in 1996.

Vehicles in this family have followed a conservative evolutionary path of development, and have been in continuous and uninterrupted production and flight for more than 45 years. Owing to this development philosophy, such vehicles have achieved a high launch rate as well as a high degree of reliability.

Table A5 - 1 shows a chronology of the most significant versions in this launch vehicle family.

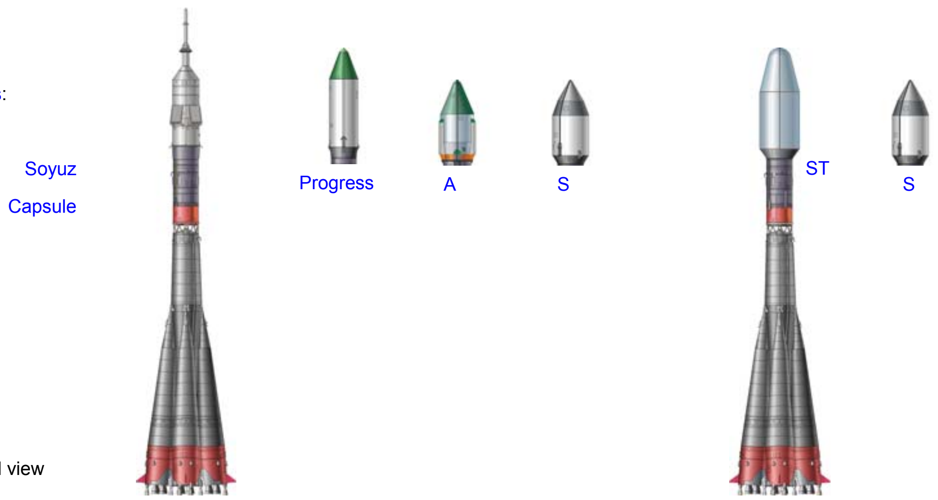
Table A5 - 1 : Soyuz (R-7) Family Evolution

General view



| Designation | **R-7A / Sputnik** | **Vostok** | **Molniya** | **Voskhod** | **Soyuz** |
|---|---|---|---|---|---|
| First launch | 1957 | 1958 | 1960 | 1963 | 1966 |
| 1st Stage | Blocks B,V,G,D | Blocks B,V,G,D | Blocks B,V,G,D | Blocks B,V,G,D | Blocks B,V,G,D |
| 2nd Stage | Block A | Block A | Block A | Block A | Block A |
| 3rd Stage | - | Block E | Block I (w/o control system) | Block I | Block I |
| 4th Stage | - | - | Block L | - | - |
| Status | Out of production | Out of production | Operational | Out of production | Out of production |

Fairings:




General view

| Designation | **Soyuz U*** | **Soyuz** |
|---|---|---|
| First launch | 1973 | Stepwise introduction from 2004 |
| 1st Stage | Blocks B,V,G,D** | Blocks B,V,G,D (enhanced FG engine) |
| 2nd Stage | Block A** | Block A (enhanced FG engine) |
| 3rd Stage | Block I | Enhanced Block I with digital control system and RD-0124 |
| 4th Stage | Ikar/ Fregat | Fregat |
| Status | Operational | Operational from CSG from 2008 onwards |

Note: * - Between 1982 and 1995 the more powerful Soyuz U2 configuration with Block A filled by synthetic fuel was used. At present, this configuration is out of production.

** - 1st and 2nd stage engines will be progressively replaced by FG configuration.

For simplification, in this User's Manual the name Soyuz refers to Soyuz with the Fregat upper stage; the configuration that is presently offered commercially.

**R-7A / Sputnik**
**1957-1960**

Used to launch the world's first artificial satellite in 1957, the Sputnik LV was a modified version of the R-7A ICBM and was designed for injection of a payload of up to 1.5 tons. The vehicle consists of just four strap-on boosters and a central core, and is considered as two-stage LV.

This vehicle launched the first three Sputnik satellites in 1957 and 1958. Soon after these missions, this two-stage LV was no longer used owing to the desire to launch larger payloads.

**Vostok**
**1958-1991**

In order to launch heavier payloads and more complex missions, the Vostok LV added a third stage to the R-7A / Sputnik LV alone. The Vostok LV essentially uses the same four strap-on boosters as the R-7A / Sputnik launch vehicle and adds a LOX/Kerosene fueled third stage (Block E) designed by the OKB-1 design bureau.

In 1959, the Vostok successfully launched the first unmanned spacecraft (Lunnik) to the moon and to achieve earth escape velocity. In 1961, the Vostok LV was also used to launch the first man (Yuri Gagarin). Owing to its limited payload capacity, the Vostok was not used for manned missions for very long, but remained operational until 1991. From 1962 to 1969, this LV was used to launch the first generation of earth observation satellites. From 1966 to 1983 it was used for meteorological and communications satellites. From 1984 to 1991, the vehicle was used less frequently for the launching of remote sensing satellites to SSO, including the Indian IRS 1A and 1B spacecraft.

## Molniya
## 1960-Present

The Molniya is a four-stage LV that replaces the Block E third stage of Vostok with a significantly more powerful LOX/kerosene Block I third stage, and adds a LOX/Kerosene nonrestartable fourth stage. This Block L fourth stage is adapted specifically for ignition in a vacuum, having been used to launch Soviet interplanetary probes before a four-stage version of the Proton LV was introduced in 1964.

From 1960 to 1964, the Molniya LV launched the following interplanetary probes: Luna-4 through 14, Mars-1, Venera-1 through 8, and Zond-1 through 3.

Since 1964, the Molniya has been used to launch Molniya communication satellites, Prognoz science satellites, military satellites, and Earth remote sensing satellites, all on highly elliptical orbits.

The introduction in 2000 of the Fregat upper stage will lead to the phasing out of the Block L stage used with Molniya, due in part to the advantages of the Fregat's restartable main engine.

## Voskhod
## 1963-1976

The Voskhod LV is essentially the first 3 stages of the Molniya vehicle. It was able to launch heavier payloads to LEO than the Vostok, and became the Soviet Union's workhorse launch vehicle of the late 1960's and early 1970's.

This vehicle was first launched in 1963 to launch the Zenit series of observation satellites. From 1964 to 1966, it was also used to launch the Voskhod series of three-crew-member manned spacecraft.

**Soyuz**

**1966-Present**

The Soyuz LV was developed from Voskhod for launching the manned Soyuz spacecraft. Initially, modifications were made to the intermediate bay of Voskhod, and a new fairing was designed with an emergency crew escape system.

Several improvements were made on the vehicle's design during the 1960's and early 1970's, cumulating in 1973 with the introduction of the Soyuz U (11A511U), which unified and standardized the improvements that had been made over the previous eight years.

This version is by far the most frequently flown, and makes up the first three stages of the Soyuz vehicle that markets for commercial use with the Fregat upper stage.

The Soyuz U2 (11A511U2) was introduced in 1982 and used synthetic kerosene ("Sintin") in the core stage to provide higher performance. The Soyuz U2 was flown 70 times and was then discontinued.

In 1999, a restartable upper stage (Ikar) based on the Kometa satellite bus was added to the lower three-stages of the Soyuz U. This LV configuration allowed the Soyuz to reach circular orbits above 500 km, and was used for six flights to deploy half (24 satellites) of the Globalstar constellation.

In 2000, the Soyuz began flying the Fregat upper stage, developed by NPO Lavochkin. It has a larger propellant capacity then the Ikar stage, and is also restartable.

In 2001 the 1-st and 2nd stage engine was upgraded. This improvement primarily involved modifying the injector pattern for the engines to improve the propellant mixing and combustion, hence raising the overall specific impulse of the engines by 5 s. Since 2001, they used permanently including manned mission.

## A5.2.2. Launch Record (1957 - 2005)

Vehicles based on the R-7 ICBM have been launched 1705 times through December 28, 2005. A breakdown of these launch attempts by vehicle class is shown below:

| Year | Launch Attempts | Failures | R-7A / Sputnik | | Vostok | | Molniya | | Voskhod | | Soyuz | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (L) | (F) | L | F | L | F | L | F | L | F | L | F |
| 1957 | 6 | 2 | 6 | 2 | | | | | | | | |
| 1958 | 11 | 8 | 8 | 5 | 3 | 3 | | | | | | |
| 1959 | 20 | 4 | 15 | 3 | 5 | 1 | | | | | | |
| 1960 | 17 | 6 | 1 | 0 | 14 | 4 | 2 | 2 | | | | |
| 1961 | 16 | 2 | | | 14 | 2 | 2 | 0 | | | | |
| 1962 | 15 | 2 | | | 9 | 1 | 6 | 1 | | | | |
| 1963 | 19 | 3 | | | 13 | 2 | 4 | 1 | 2 | 0 | | |
| 1964 | 28 | 4 | | | 14 | 0 | 8 | 4 | 6 | 0 | | |
| 1965 | 37 | 3 | | | 13 | 1 | 12 | 2 | 12 | 0 | | |
| 1966 | 40 | 4 | | | 15 | 1 | 9 | 1 | 14 | 1 | 2 | 1 |
| 1967 | 40 | 3 | | | 9 | 0 | 7 | 0 | 20 | 3 | 4 | 0 |
| 1968 | 42 | 2 | | | 2 | 0 | 6 | 1 | 29 | 1 | 5 | 0 |
| 1969 | 44 | 1 | | | 3 | 1 | 4 | 0 | 32 | 0 | 5 | 0 |
| 1970 | 44 | 1 | | | 5 | 0 | 7 | 0 | 30 | 1 | 2 | 0 |
| 1971 | 44 | 4 | | | 5 | 0 | 3 | 0 | 31 | 4 | 5 | 0 |
| 1972 | 48 | 1 | | | 5 | 0 | 11 | 0 | 29 | 1 | 3 | 0 |
| 1973 | 54 | 1 | | | 3 | 0 | 10 | 0 | 32 | 1 | 9 | 0 |
| 1974 | 52 | 3 | | | 6 | 0 | 7 | 0 | 24 | 2 | 15 | 1 |
| 1975 | 59 | 1 | | | 6 | 0 | 12 | 0 | 28 | 0 | 13 | 1 |
| 1976 | 55 | 1 | | | 5 | 0 | 11 | 0 | 12 | 0 | 27 | 1 |
| 1977 | 56 | 2 | | | 7 | 0 | 10 | 0 | | | 39 | 2 |
| 1978 | 59 | 0 | | | 5 | 0 | 9 | 0 | | | 45 | 0 |
| 1979 | 62 | 2 | | | 8 | 0 | 7 | 0 | | | 47 | 2 |
| 1980 | 64 | 1 | | | 7 | 1 | 12 | 0 | | | 45 | 0 |
| 1981 | 62 | 1 | | | 6 | 0 | 14 | 0 | | | 42 | 1 |
| 1982 | 61 | 2 | | | 5 | 0 | 11 | 0 | | | 45 | 2 |
| 1983 | 58 | 1 | | | 4 | 0 | 11 | 0 | | | 43 | 1 |
| 1984 | 55 | 0 | | | | | 11 | 0 | | | 44 | 0 |
| 1985 | 57 | 0 | | | 1 | 0 | 16 | 0 | | | 40 | 0 |
| 1986 | 51 | 1 | | | | | 14 | 0 | | | 37 | 1 |
| 1987 | 48 | 1 | | | | | 4 | 0 | | | 44 | 1 |
| 1988 | 58 | 3 | | | 2 | 0 | 11 | 0 | | | 45 | 3 |
| 1989 | 44 | 0 | | | | | 6 | 0 | | | 38 | 0 |
| 1990 | 44 | 2 | | | | | 12 | 0 | | | 32 | 2 |
| 1991 | 30 | 0 | | | 1 | 0 | 5 | 0 | | | 24 | 0 |
| 1992 | 32 | 0 | | | | | 8 | 0 | | | 24 | 0 |
| 1993 | 25 | 0 | | | | | 8 | 0 | | | 17 | 0 |
| 1994 | 18 | 0 | | | | | 3 | 0 | | | 15 | 0 |
| 1995 | 16 | 0 | | | | | 4 | 0 | | | 12 | 0 |
| 1996 | 12 | 2 | | | | | 3 | 0 | | | 9 | 2 |
| 1997 | 13 | 0 | | | | | 3 | 0 | | | 10 | 0 |
| 1998 | 11 | 0 | | | | | 3 | 0 | | | 8 | 0 |
| 1999 | 14 | 0 | | | | | 2 | 0 | | | 12 | 0 |
| 2000 | 13 | 0 | | | | | | | | | 13 | 0 |
| 2001 | 11 | 0 | | | | | 2 | 0 | | | 9 | 0 |
| 2002 | 9 | 1 | | | | | 2 | 0 | | | 7 | 1 |
| 2003 | 10 | 0 | | | | | 2 | 0 | | | 8 | 0 |
| 2004 | 9 | 0 | | | | | 1 | 0 | | | 8 | 0 |
| 2005 | 5 | 1 | | | | | 1 | 1 | | | 4 | 0 |
| **Totals** | **1698** | **75** | **30** | **10** | **195** | **17** | **316** | **13** | **301** | **14** | **856** | **22** |

### A5.2.3. Detailed Launch Record 1996 - 2003

Since Soyuz entry to the commercial market in 1996 there has been TBD successful launches within TBDlaunch attempts.

Table A5 - 2 shows a detailed log of all launches since 1996.

**Table A5 - 2 : Record of Soyuz (R-7) Launch Vehicle Family (1996 - 2003)**

| Date | Launch Site | Launch Vehicle | Manned / Unmanned | Payload | Success | Failure | LV Family Flight Number | Soyuz Flight Number |
|---|---|---|---|---|---|---|---|---|
| February 21, 1996 | Baikonur | Soyuz U | Manned | Soyuz TM-23 | X | | 1592 | 769 |
| March 14, 1996 | Plesetsk | Soyuz U | Unmanned | Kosmos-2331 | X | | 1593 | 770 |
| May 5, 1996 | Baikonur | Soyuz U | Unmanned | Progress M-31 | X | | 1594 | 771 |
| May 14, 1996 | Baikonur | Soyuz U | Unmanned | Kosmos | | X | 1595 | 772 |
| June 20, 1996 | Plesetsk | Soyuz U | Unmanned | Yantar-4K2 | | X | 1596 | 773 |
| July 31, 1996 | Baikonur | Soyuz U | Unmanned | Progress M-32 | X | | 1597 | 774 |
| August 15, 1996 | Plesetsk | Molniya | Unmanned | Molniya-1T | X | | 1598 | |
| August 17, 1996 | Baikonur | Soyuz U | Manned | Soyuz TM-24 | X | | 1599 | 775 |
| August 29, 1996 | Plesetsk | Molniya | Unmanned | Prognoz-M2 | X | | 1600 | |
| October 24, 1996 | Plesetsk | Molniya | Unmanned | Molniya-3 | X | | 1601 | |
| November 20, 1996 | Baikonur | Soyuz U | Unmanned | Progress M-33 | X | | 1602 | 776 |
| December 24, 1996 | Plesetsk | Soyuz U | Unmanned | Bion-11 | X | | 1603 | 777 |
| February 10, 1997 | Baikonur | Soyuz U | Manned | Soyuz TM-25 | X | | 1604 | 778 |
| April 6, 1997 | Baikonur | Soyuz U | Unmanned | Progress M-34 | X | | 1605 | 779 |
| April 9, 1997 | Plesetsk | Molniya | Unmanned | Kosmos-2340 | X | | 1606 | |
| May 14, 1997 | Plesetsk | Molniya | Unmanned | Kosmos-2342 | X | | 1607 | |
| May 15, 1997 | Baikonur | Soyuz U | Unmanned | Kosmos-2343 | X | | 1608 | 780 |
| July 5, 1997 | Baikonur | Soyuz U | Unmanned | Progress M-35 | X | | 1609 | 781 |
| August 5, 1997 | Baikonur | Soyuz U | Manned | Soyuz TM-26 | X | | 1610 | 782 |
| September 25, 1997 | Plesetsk | Molniya | Unmanned | Molniya-1T | X | | 1611 | |
| October 5, 1997 | Baikonur | Soyuz U | Unmanned | Progress M-36 | X | | 1612 | 783 |
| October 9, 1997 | Plesetsk | Soyuz U | Unmanned | Foton-11 | X | | 1613 | 784 |
| November 18, 1997 | Plesetsk | Soyuz U | Unmanned | Resurs-F1M | X | | 1614 | 785 |
| December 15, 1997 | Plesetsk | Soyuz U | Unmanned | Kosmos-2348 | X | | 1615 | 786 |
| December 20, 1997 | Baikonur | Soyuz U | Unmanned | Progress M-37 | X | | 1616 | 787 |
| January 29, 1998 | Baikonur | Soyuz U | Manned | Soyuz TM-27 | X | | 1617 | 788 |
| February 17, 1998 | Baikonur | Soyuz U | Unmanned | Kosmos-2349 | X | | 1618 | 789 |
| March 15, 1998 | Baikonur | Soyuz U | Unmanned | Progress M-38 | X | | 1619 | 790 |
| May 7, 1998 | Plesetsk | Molniya | Unmanned | Kosmos-2351 | X | | 1620 | |
| May 15, 1998 | Baikonur | Soyuz U | Unmanned | Progress M-39 | X | | 1621 | 791 |
| June 24, 1998 | Plesetsk | Soyuz U | Unmanned | Kosmos-2358 | X | | 1622 | 792 |
| June 25, 1998 | Baikonur | Soyuz U | Unmanned | Kosmos-2359 | X | | 1623 | 793 |
| July 1, 1998 | Plesetsk | Molniya | Unmanned | Molniya-3 | X | | 1624 | |
| August 13, 1998 | Baikonur | Soyuz U | Manned | Soyuz TM-28 | X | | 1625 | 794 |
| September 29, 1998 | Plesetsk | Molniya | Unmanned | Molniya-1T | X | | 1626 | |
| October 25, 1998 | Baikonur | Soyuz U | Unmanned | Progress M-40 | X | | 1627 | 795 |
| February 9, 1999 | Baikonur | Soyuz U (Ikar) | Unmanned | Globalstar FM36, 23, 38, 40 | X | | 1628 | 796 |
| February 20, 1999 | Baikonur | Soyuz U | Manned | Soyuz TM-29 | X | | 1629 | 797 |

| Date | Launch Site | Launch Vehicle | Manned / Unmanned | Payload | Success | Failure | LV Family Flight Number | Soyuz Flight Number |
|---|---|---|---|---|---|---|---|---|
| March 15, 1999 | Baikonur | Soyuz U (Ikar) | Unmanned | Globalstar FM22, 41, 46, 37 | X | | 1630 | 798 |
| April 2, 1999 | Baikonur | Soyuz U | Unmanned | Progress M-41 | X | | 1631 | 799 |
| April 15, 1999 | Baikonur | Soyuz U (Ikar) | Unmanned | Globalstar FM19, 42, 44, 45 | X | | 1632 | 800 |
| July 8, 1999 | Plesetsk | Molniya | Unmanned | Molniya-3 | X | | 1633 | |
| July 16, 1999 | Baikonur | Soyuz U | Unmanned | Progress M-42 | X | | 1634 | 801 |
| August 18, 1999 | Plesetsk | Soyuz U | Unmanned | Kosmos-2365 | X | | 1635 | 802 |
| September 9, 1999 | Plesetsk | Soyuz U | Unmanned | Foton-12 | X | | 1636 | 803 |
| September 22, 1999 | Baikonur | Soyuz U (Ikar) | Unmanned | Globalstar FM33, 50, 55, 58 | X | | 1637 | 804 |
| September 28, 1999 | Plesetsk | Soyuz U | Unmanned | Resurs-F1M | X | | 1638 | 805 |
| October 18, 1999 | Baikonur | Soyuz U (Ikar) | Unmanned | Globalstar FM31, 56, 57, 59 | X | | 1639 | 806 |
| November 22, 1999 | Baikonur | Soyuz U (Ikar) | Unmanned | Globalstar FM29, 34, 39, 61 | X | | 1640 | 807 |
| December 27, 1999 | Plesetsk | Molniya | Unmanned | Kosmos-2368 | X | | 1641 | |
| January 2, 2000 | Baikonur | Soyuz U | Unmanned | Progress M1-1 | X | | 1642 | 808 |
| February 9, 2000 | Baikonur | Soyuz U (Fregat) | Unmanned | IRDT | X | | 1643 | 809 |
| March 20, 2000 | Baikonur | Soyuz U (Fregat) | Unmanned | DUMSAT | X | | 1644 | 810 |
| April 4, 2000 | Baikonur | Soyuz U | Manned | Soyuz TM-30 | X | | 1645 | 811 |
| April 25, 2000 | Baikonur | Soyuz U | Unmanned | Progress M1-2 | X | | 1646 | 812 |
| May 3, 2000 | Baikonur | Soyuz U | Unmanned | Kosmos-2370 | X | | 1647 | 813 |
| July 16, 2000 | Baikonur | Soyuz U (Fregat) | Unmanned | Cluster-II FM6, 7 (Samba, Salsa) | X | | 1648 | 814 |
| August 6, 2000 | Baikonur | Soyuz U | Unmanned | Progress M1-3 | X | | 1649 | 815 |
| August 9, 2000 | Baikonur | Soyuz U (Fregat) | Unmanned | Cluster-II FM5, 8 (Rumba, Tango) | X | | 1650 | 816 |
| September 29, 2000 | Baikonur | Soyuz U | Unmanned | Kosmos-2373 | X | | 1651 | 817 |
| October 15, 2000 | Baikonur | Soyuz U | Unmanned | Progress M-43 | X | | 1652 | 818 |
| October 31, 2000 | Baikonur | Soyuz U | Manned | Soyuz TM-31 | X | | 1653 | 819 |
| November 16, 2000 | Baikonur | Soyuz U | Unmanned | Progress M1-4 | X | | 1654 | 820 |
| January 24, 2001 | Baikonur | Soyuz U | Unmanned | Progress M1-5 | X | | 1655 | 821 |
| February 26, 2001 | Baikonur | Soyuz U | Unmanned | Progress M-44 | X | | 1656 | 822 |
| April. 28, 2001 | Baikonur | Soyuz U | Manned | Soyuz TM-32 | X | | 1657 | 823 |
| May 21, 2001 | Baikonur | Soyuz FG | Unmanned | Progress M1-6 | X | | 1658 | 824 |
| May 29, 2001 | Plesetsk | Soyuz U | Unmanned | Kosmos 2377 | X | | 1659 | 825 |
| July 20, 2001 | Plesetsk | Molniya-M | Unmanned | Molnia-3K | X | | 1660 | |
| August 21, 2001 | Baikonur | Soyuz U | Unmanned | Progress M-45 | X | | 1661 | 826 |
| September 14, 2001 | Baikonur | Soyuz U | Unmanned | Progress-M-SO1 w/ Stikovochniy Otsek 1 | X | | 1662 | 827 |
| October 21, 2001 | Baikonur | Soyuz U | Manned | Soyuz TM-33 | X | | 1663 | 828 |
| October 25, 2001 | Plesetsk | Molniya- | Unmanned | Molniya 3 | X | | 1664 | |

| Date | Launch Site | Launch Vehicle | Manned / Unmanned | Payload | Success | Failure | LV Family Flight Number | Soyuz Flight Number |
|---|---|---|---|---|---|---|---|---|
| | | M | | | | | | |
| November 26, 2001 | Baikonur | Soyuz FG | Unmanned | Progress M1-7 | X | | 1665 | 829 |
| February 25, 2002 | Plesetsk | Soyuz U | Unmanned | Kosmos 2387 | X | | 1666 | 830 |
| March 21, 2002 | Baikonur | Soyuz U | Unmanned | Progress M1-8 | X | | 1667 | 831 |
| April 1, 2002 | Plesetsk | Molniya-M | Unmanned | Kosmos 2388 | X | | 1668 | |
| April 25, 2002 | Baikonur | Soyuz U | Manned | Soyuz TM-34 | X | | 1669 | 832 |
| June 26, 2002 | Baikonur | Soyuz U | Unmanned | Progress M-46 | X | | 1670 | 833 |
| September 25, 2002 | Baikonur | Soyuz FG | Unmanned | Progress M1-9 | X | | 1671 | 834 |
| October 15, 2002 | Plesetsk | Soyuz U | Unmanned | Photon-M N1 | | X | 1672 | 835 |
| October 30, 2002 | Baikonur | Soyuz FG | Manned | Soyuz TMA-1 | X | | 1673 | 836 |
| December 24, 2002 | Plesetsk | Molniya-M | Unmanned | Kosmos-2393 | X | | 1674 | |
| February 02, 2003 | Baikonur | Soyuz U | Unmanned | Progress-M47 | X | | 1675 | 837 |
| April 02, 2003 | Plesetsk | Molniya-M | Unmanned | Molnia-1T | X | | 1676 | |
| April 26, 2003 | Baikonur | Soyuz FG | Manned | Soyuz TMA-2 | X | | 1677 | 838 |
| June 02, 2003 | Baikonur | Soyuz FG | Unmanned | Mars Express | X | | 1678 | 839 |
| June 08, 2003 | Baikonur | Soyuz U | Unmanned | Progress M1-10 | X | | 1679 | 840 |
| June 19, 2003 | Plesetsk | Molniya-M | Unmanned | Molnia-3 | X | | 1680 | |
| August 12, 2003 | Baikonur | Soyuz U | Unmanned | Cosmos-2399 | X | | 1681 | 841 |
| August 29, 2003 | Baikonur | Soyuz U | Unmanned | Progress-M48 | X | | 1682 | 842 |
| October 18, 2003 | Baikonur | Soyuz FG | Manned | Soyuz TMA-3 | X | | 1683 | 843 |
| December 27, 2003 | Baikonur | Soyuz FG (Fregat) | Unmanned | AMOS-2 | X | | 1684 | 844 |
| January 29, 2004 | Baikonur | Soyuz FG | Unmanned | Progress M1-11 | X | | 1685 | 845 |
| February 18, 2004 | Plesetsk | Molniya-M | Unmanned | Molniya 1-93 | X | | 1686 | |
| April 19, 2004 | Baikonur | Soyuz FG | Manned | Soyuz TMA-4 | X | | 1687 | 846 |
| May 25, 2004 | Baikonur | Soyuz U | Unmanned | Progress M-49 | X | | 1688 | 847 |
| August 11, 2004 | Baikonur | Soyuz U | Unmanned | Progress M-50 | X | | 1689 | 848 |
| September 24, 2004 | Baikonur | Soyuz U | Unmanned | Cosmos 2410 | X | | 1690 | 849 |
| October 14, 2004 | Baikonur | Soyuz FG | Manned | Soyuz TMA-5 | X | | 1691 | 850 |
| November 8, 2004 | Plesetsk | Soyuz 2-1a | Unmanned | Test payload (Oblick) | X | | 1692 | 851 |
| December 24, 2004 | Baikonur | Soyuz U | Unmanned | Progress M-51 | X | | 1693 | 852 |

| Date | Launch Site | Launch Vehicle | Manned / Unmanned | Payload | Success | Failure | LV Family Flight Number | Soyuz Flight Number |
|---|---|---|---|---|---|---|---|---|
| February 28, 2005 | Baikonur | Soyuz U | Unmanned | Progress M-52 | X | | 1694 | 853 |
| April 15, 2005 | Baikonur | Soyuz FG | Manned | Soyuz TMA-6 | X | | 1695 | 854 |
| May 31, 2005 | Baikonur | Soyuz U | Unmanned | Foton M2 | X | | 1696 | 855 |
| June 17, 2005 | Baikonur | Soyuz U | Unmanned | Progress M-53 | X | | 1697 | 856 |
| June 21, 2005 | Plesetsk | Molniya-M | Unmanned | Molnia-3K | | X | 1698 | |
| August 14, 2005 | Baikonur | Soyuz FG (Fregat) | Unmanned | Galaxy 14 | X | | 1699 | 857 |
| September 2, 2005 | Baikonur | Soyuz | Unmanned | | X | | 1700 | 858 |
| September 8, 2005 | Baikonur | Soyuz U | Unmanned | Progress M-54 | X | | 1701 | 859 |
| October 1, 2005 | Baikonur | Soyuz FG | Manned | Soyuz TMA-7 | X | | 1702 | 860 |
| November 9, 2005 | Baikonur | Soyuz FG (Fregat) | Unmanned | Venus Express | X | | 1703 | 861 |
| December 21, 2005 | Baikonur | Soyuz U | Unmanned | Progress M-55 | X | | 1704 | 862 |
| December 28, 2005 | Baikonur | Soyuz FG (Fregat) | Unmanned | GIOVE-A | X | | 1705 | 863 |
| | | | | | | | | |
| | | | | | | | | |

The two failures listed in 1996 (May 14 and June 20) were due to a manufacturing defect of the fairing release mechanism. Since the fairings for the two flights were manufactured in a batch, the same defect was repeated on both fairings. The cause was identified, other fairings in the batch were repaired, and corrective actions were taken to ensure that this defect was not repeated.

The failure on October 15, 2002 was due to a particle in the hydrogen peroxide circuit running the turbopump of the 1-st stage booster. This anomaly was detected after 37 successful launches of the same production batch. Nevertheless comprehensive corrective actions were taken in the design of the questionable element, production, operation and preparation to the launch.

The last failure occurred on June 21st, 2005 with a Molnya launch vehicle. The block A on Molnya operates close to the maximim flow rate acceptable by the RD 0108 (which is not the case of Soyuz), specific engine and flow control block characteristics on that flight led to engine operating range to be exceeded. These deviated conditions provoked kerozene leak, and therefore oxygen flow increase. The block I engine was ignited at a time when block A propellant were depleted, leading to turbopump explosion and then to vehicle loss of control. These anomaly is inherently linked to the Molnya launch vehicle characteristics, and in no way affects Soyuz launches.